# RSALOP

## *Radionuclide Soil Action Levels Oversight Panel*

# *Risk Assessment Corporation*

Proposal & Contract

*Compiled by:*

AIMSI


Advanced Integrated Management Services, Inc.
5460 Ward Road, Suite 370
Arvada, CO 80002
(303) 456-0884 fax. (303) 456-0858



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**CONTRACT FOR SERVICES**

**BETWEEN**

**ROCKY FLATS CITIZENS ADVISORY BOARD**

**AND**

**RISK ASSESSMENT CORPORATION**

**REGARDING TECHNICAL SERVICES FOR**

**ROCKY FLATS SOIL ACTION LEVELS PROJECT**

THIS CONTRACT FOR SERVICES is entered into as of this 1st day of October, 1998, by and between the Rocky Flats Citizens Advisory Board, a 501(c)(3) non-profit Colorado corporation ("RFCAB"), and Risk Assessment Corporation, a sole proprietorship, authorized to do business in the State of Colorado ("Contractor").

**RECITALS**

WHEREAS, RFCAB is a 501(c)(3) non-profit Colorado corporation, with a purpose to promote public education regarding the Rocky Flats Environmental Technology Site ("Rocky Flats"), and is the designated site specific advisory board for Rocky Flats, as determined by the U.S. Department of Energy ("DOE"); and

WHEREAS, the DOE has designated RFCAB as the appropriate entity to manage and finance, with DOE funds, a project regarding an independent analysis of the soil action levels at the Rocky Flats Environmental Technology Site ("RFETS"); and

WHEREAS, various individuals representing the public and private sector surrounding Rocky Flats have established an *ad hoc* committee and oversight panel for the purpose of having an independent review source of the soil action levels project (the "Oversight Panel"); and

WHEREAS, RFCAB desires to use Contractor to render such services to RFCAB, with the assistance of the Oversight Panel as described herein, and Contractor desires to perform such services for RFCAB;

NOW THEREFORE, in consideration of the mutual covenants and agreements hereinafter set forth, the sufficiency of which is hereby acknowledged, the parties do hereto agree as follows:

## COVENANTS AND AGREEMENTS

1. **SCOPE OF SERVICES**. Contractor shall be responsible for performing all things stated in the Scope of Services attached as Exhibit A in connection with the performance of a independent scientific review of the radiological soil action levels established for the cleanup of RFETS (collectively referred to as the "Services" and broken down into individual Tasks), as desired by RFCAB. The Services include the completion of seven (7) defined milestones ("Milestones"), all as specified in Exhibit A. Contractor shall perform such Services as set forth herein, and as may be directed, from time to time, by RFCAB or by the Oversight Panel in accordance with Exhibit A, using that degree of skill and knowledge customarily employed by others performing similar services in the United States. Any direction of Services from the Oversight Panel shall be from either of its Co-Chairs, Hank Stovall or Mary Harlow.

2. **TERM OF CONTRACT**. The term of this Contract shall begin on the effective date of execution set forth above and shall expire on the 30th day of November, 1999, or when all Services have been performed, whichever date first occurs, or by exercise of the termination provisions specified in paragraph 11, herein.

3. **TIME OF THE ESSENCE**. Contractor shall undertake and complete the Services in such sequence as to assure their expeditious completion no later than November 30, 1999.

4. **COMPENSATION**. RFCAB will compensate Contractor for the Services performed in the amounts and at the rates set forth in the Payment and Rate Schedule, attached hereto and incorporated herein as Exhibit B. Compensation, including approved direct costs, shall not exceed the amount of $470,000. Allowable direct costs incurred by Contractor in connection with the Services which are eligible for reimbursement by RFCAB shall be limited to approved travel costs and costs of production and distribution of the final project report, which direct costs shall not exceed $55,242, as shown on the Payment and Rate Schedule.

RFCAB shall withhold from each payment to be made to Contractor pursuant to this paragraph an amount equal to ten percent (10%) of such payment. All amounts withheld pursuant to this paragraph shall be held by RFCAB until satisfactory completion of the Services. In connection with the Completion of the Services, Contractor shall submit to RFCAB an executed Certificate of Completion, a sample of which certificate is attached hereto and incorporated herein as Exhibit C. Upon acknowledgment by RFCAB of satisfactory completion of all Services and RFCAB's execution of the Certificate of Completion, RFCAB shall release the withheld funds to Contractor.

5. **REQUIREMENT FOR AND METHOD OF PAYMENT**. To obtain payment for Services rendered, Contractor shall submit to RFCAB a detailed invoice for each Milestone completed. Each invoice shall include: (1) a narrative description of the Services



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performed during that Milestone period; (2) the number of hours, or portion of an hour, expended to perform the Services; and (3) the total number of hours spent to date and the total remaining number of hours budgeted for the completion of all Services. Contractor shall provide an explanation of any variances in the number of hours spent from the estimate shown on the Payment and Rate Schedule. RFCAB acknowledges that Contractor may, subject to approval by RFCAB or the Oversight Panel, adjust the estimated hours budgeted for subsequent Milestones with the variances, in the event necessary and so long as such adjustment(s) is reflected on the applicable invoice. Upon RFCAB's satisfaction with and approval of an invoice, payment for the Services shall be made by RFCAB within thirty (30) days. Contractor shall submit invoices to RFCAB for direct costs on a monthly basis for payment in accordance with this paragraph.

6. <u>INDEPENDENT CONTRACTOR</u>. Contractor is an independent contractor and nothing herein contained shall constitute or designate Contractor or any of its employees or agents as employees or agents of RFCAB.

7. <u>CONTRACTOR'S INSURANCE</u>. Contractor shall acquire and maintain, during the term of this Contract, including any extensions of the term, statutory workers' compensation insurance coverage (if applicable), commercial general liability insurance coverage and auto liability insurance, in the minimum amounts set forth below:

<u>Workers compensation insurance</u>: in accordance with applicable law; and

<u>Commercial general liability insurance</u>: in the minimum amount of $1,000,000 general aggregate.

<u>Auto Liability Insurance</u>: in the minimum amount of $1,000,000, covering any automobile.

8. <u>INDEMNIFICATION</u>. Contractor hereby agrees to indemnify and hold harmless RFCAB and each of its directors, employees, agents and consultants, from and against any and all claims, demands, losses, liabilities, actions, lawsuits and expenses (including reasonable attorneys' fees), arising directly or indirectly, in whole or in part, from the negligence or any criminal or tortious act or omission of Contractor or any of its agents or employees, in connection with this Contract and/or Contractor's Services or work hereunder, whether within or beyond the scope of its, his or her duties or authority hereunder. The provisions of this paragraph 8 shall survive termination of this Contract.

9. <u>ASSIGNMENT</u>. Neither party shall assign this Contract or parts thereof, or his or her respective duties, without the express written consent of the other party.

10. <u>SUBCONTRACTORS.</u> RFCAB requires approval of the use of any subcontractor by Contractor. Contractor is solely and fully responsible to RFCAB for the Services.



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11. **TERMINATION.**

a. RFCAB may terminate this Contract not-for-cause in whole or in part, by delivering to Contractor a written notice of such termination specifying the extent of termination and the effective date. If this Contract is terminated, RFCAB shall pay Contractor for Services satisfactorily performed prior to the designated termination date.

b. Contractor may terminate this Contract in the event that it reasonably determines that actions of DOE are impeding Contractor's ability to independently perform the Services required. Upon such a determination, Contractor may terminate this Contract by delivering to RFCAB, at least ten days prior to the effective date of termination, a written notice of such termination specifying the reasons for termination and the effective date. Upon the effective date of termination, the total cost of the Services satisfactorily performed to the date of termination for cause shall be determined by RFCAB, excluding any demobilization costs. All damages, losses, costs and charges incurred by RFCAB, including attorney's fees and costs, relating to obtaining and mobilizing another contractor, of completing the Services and of retaining another contractor's acceptance of full responsibility for all obligations of the Contractor under this Contract shall be deducted from any monies due or which may become due to the Contractor.

12. **CONDITION TO FUNDING.** The Contractor acknowledges and agrees that RFCAB's performance under this Contract, including compensation to be paid to the Contractor hereunder, is expressly conditioned upon the availability of funds under RFCAB's grant with the DOE. In the event such grant funds are not made available to RFCAB, then this Contract may be terminated

13. **WORK PRODUCT**. All work product of Contractor prepared pursuant this Contract, including but not limited to all maps, plans, drawings, specifications, reports, electronic files and other documents, in whatever form ("Work Product"), shall become the property of RFCAB under all circumstances, regardless of whether Contractor is terminated. All Work Product shall be provided to RFCAB at the time of completion of any of the Services described in Exhibit A, at the request of RFCAB, or in any event, at the time of termination of this Contract. At any time, RFCAB may obtain reproducible copies of Contractor's Work Product.

14. **NOTICES**. Any notices or other communications required or permitted by this Contract or by law to be served on, given to, or delivered to any party hereto, by any party shall be in writing and shall be deemed duly served, given, or delivered when personally delivered to the party to whom it is addressed, or in lieu of such personal services, when deposited in the United States' mail, first-class postage prepaid, addressed to RFCAB at:



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Rocky Flats Citizens Advisory Board
9035 Wadsworth Parkway, Suite 2250
Westminster, CO 80021
Attn: Ken Korkia
Phone: (303) 420-7855
Facsimile: (303) 420-7579

with a copy to:

Ankele, Icenogle, Norton & Seter, P.C.
5690 DTC Boulevard, Suite 300
Greenwood Village, CO 80111
Attn: Barbara K. Tenney

or to Contractor at:

Risk Assessment Corporation
417 Till Road
Neeses, SC 29107
Attn: John E. Till, President
Phone: (803) 536-4883
Facsimile: (803) 534-1995

with a copy to:

Denham Consulting, Inc.
6319 Poplar Bluff Circle
Norcross, GA 30092

Attn: Ms. Leeann S. Denham

Either party may change its address for the purpose of this paragraph by giving written notice of such change to the other parties in the manner provided in this paragraph.

15. <u>ENTIRE AGREEMENT</u>. This Contract constitutes the entire agreement between the parties hereto relating to the Services and sets forth the rights, duties, and obligations of each party as of this date. Any prior agreements, promises, negotiations, or representations not expressly set forth in this Contract are of no force and effect.

16. <u>AMENDMENT</u>. This Contract, including the Scope of Services, Exhibit A, and the Payment and Rate Schedule, Exhibit B, shall be amended only by a writing mutually agreed upon and executed by all parties.



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17. **BINDING AGREEMENT**. This Contract shall inure to and be binding on the heirs, executors, administrator, successors, and assigns of the parties hereto.

18. **NO WAIVER**. No waiver of any of the provisions of this Contract shall be deemed to constitute a waiver of any other of the provisions of this Contract, nor shall such waiver constitute a continuing waiver unless otherwise expressly provided herein, nor shall the waiver of any default hereunder be deemed a waiver of any subsequent default hereunder.

19. **CONTROLLING LAW**. This Contract shall be governed by and construed in accordance with the law of the State of Colorado.

20. **COMPLIANCE WITH LAWS**. Contractor shall keep fully informed regarding, and shall fully and timely comply with, all federal, state and local laws, ordinances, rules and regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority that may affect those engaged on employees in the performance of this Contract. Contractor shall observe all rules and regulations of federal, state and local health officials.

21. **FEDERAL PROVISIONS**. This Contract is awarded pursuant to a grant received by RFCAB under the direction of the U.S. Department of Energy and, in compliance with the requirements imposed by the awarding federal agency, including without limitation:

A. All Work Product, as defined in paragraph 14, shall be subject to the copyright and publishing provisions of the Department of Energy regulations.

B. All Work Product, as defined in paragraph 14, shall be subject to the Department of Energy's policies and procedures concerning patent rights.

C. The Department of Energy requires that RFCAB submit annual reports to the Department of Energy for each year that RFCAB continues to receive federal assistance, and for one year thereafter, which reports shall include the status of RFCAB's activities funded by the grant, the costs incurred for each completed and/or partially activity, and any operational costs of activities, the degree to which the activities have achieved their goals, and the overall effectiveness of the economic assistance provided in meeting the adjustment needs of the area.

D. RFCAB, the Department of Energy, the Comptroller General of the United States, or any of their duly authorized representatives shall have access to any books, documents, papers, and records of Contractor which are directly pertinent to this Contract for the purpose of making audit, examination, excerpts and transcriptions.

E. All required records developed in connection with this Contract shall be retained for a period of three years after RFCAB makes final payment to Contractor and all other pending matters are closed.

F. This Contract is further subject to the following DOE-required federal rules and regulations:

1) Assurances – Non-Construction Programs
2) 10 CFR Part 1040 – Assurance of Compliance, Nondiscrimination in Federally Assisted Programs
3) 10 CFR Part 1036 – Certification Regarding Debarment, Suspension, and Other Responsibility Matters – Primary Covered Transactions
4) 10 CFR Part 601 – Restrictions on Lobbying
5) 10 CFR Part 1036, Appendix C – Certification Regarding Drug-Free Workplace Requirements

22. <u>**COUNTERPART EXECUTION**</u>. This Contract may be executed in counterparts, each of which shall be deemed an original, and all of which together shall constitute one and the same instrument.

ROCKY FLATS CITIZENS ADVISORY BOARD

[signature]

By:
Its: Chair

ATTEST:

[signature]



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RISK ASSESSMENT CORPORATION

By:
Its: President

ATTEST:

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**EXHIBIT A**

**Scope of Services**

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## EXHIBIT A

### Scope of Services

The following Work Tasks and Deliverables will be completed by the Contractor in performance of the Services for this Contract.

### Task 1. Cleanup Levels at Other Sites

1. Evaluate all available soil cleanup and/or action level studies performed for either specific or generic sites.
2. Compare these cleanup levels at other sites with those proposed for RFETS.
3. Discuss the methods, assumptions, and relative merits of each study and its applicability to the RFETS environment.
4. Identify the models and methods used in these studies that may be applicable to the RFETS environment.
5. Document findings in a report.

**Deliverables:**

1. Meet with the Oversight Panel and present latest findings, address concerns, and discuss future direction.
2. A draft report will be delivered by February 8, 1999.
3. A final report will be delivered by May 8, 1999.

### Task 2. Computer Models

1. RAC will search for existing or developmental computer programs that estimate radiation dose rate to an individual as a function of that individual's exposure to soils contaminated with radionuclides.
2. The programs will be evaluated for suitability for site-specific use at RFETS, and RESRAD will be included in the evaluation.
3. A summary report will describe the programs and recommend a program or prescribed use of a combination of programs for analyzing and establishing soil actions levels for RFETS.
4. The search will include some general environmental assessment programs, which could have the capability of considering offsite migrations of radioactivity.
5. Recommendations will include the problem of extending validation of models and programs for RFETS applicability.

**Deliverables:**

1. Meet with the Oversight Panel and present latest findings, address concerns, and discuss future direction.
2. A draft report will be delivered by March 8, 1999.
3. A final report will be delivered in July 8, 1999.

### Task 3. Inputs and Assumptions

1. Evaluate input parameters, default inputs, and assumptions for adequacy, accuracy, and credibility concerning current and future land use scenarios and conversion to dose rate/contamination levels. This includes evaluating exposure scenarios defined for soil

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action levels in terms of their credibility for addressing doses for future land use scenarios.

2. Perform a sensitivity analysis of one parameter at a time with RESRAD using the cases developed for the proposed soil action levels. Determine which parameters are unlikely to contribute substantially to the overall uncertainty in the soil action levels. Consideration will be given to the sensitivity of the individual parameter and how that parameter is used in the underlying RESRAD equations.
3. Develop uncertainty distributions for parameters that are not selected in (1) from site-specific data if available. Literature will be reviewed if site-specific date does not exist.
4. Write a computer interface for RESRAD that performs Monte Carlo calculations on the parameters not selected in (1) and stores output.
5. Perform Monte Carlo simulations using the distributions developed in (2) for the exposure scenarios defined for the proposed soil action levels and any alternate scenarios the Oversight Panel wishes to include.
6. Extract from the Monte Carlo output, the sensitivity of the soil action levels to each input parameter, and the uncertainty on the overall action levels. Report results by exposure scenario.
7. Document and interpret results in a report.

**Deliverables:**

1. Meet with the Oversight Panel and present latest findings, address concerns, and discuss future direction.
2. A draft report will be delivered by July 8, 1999.
3. A final report will be delivered in October 8, 1999.

## Task 4. Methodology

1. RAC will review the approaches to interpretation of data and results in simulation ("methodologies") and develop a discussion of these approaches.
2. No later than one month after the beginning of this contract, RAC will present the discussion of item 1 to the Oversight Panel and stakeholders.
3. RAC will recommend to the Oversight Panel an approach, based on state-of-the-art methods of uncertainty analysis, to relate concentrations in soil to annual radiation doses to individuals represented in specific exposure scenarios.

**Deliverables:**

1. Meet with Oversight Panel and present methodology approaches for interpretation of data and results by November 1999.
2. Incorporate discussion items into the methodology used in the independent calculation of soil action levels. Incorporate findings in appendix of final report.

## Task 5. Independent Calculation

1. The computer programs identified in Task 2 will be used to calculate soil action levels, using the methodology identified in Task 4.
2. Programs will be set up to carry out Monte Carlo uncertainty analysis with the calculations. RAC will estimate probability distributions for soil action levels, interpret the distributions, and provide a statement of confidence in the results.
3. Soil action levels will be derived for each of the land use scenarios assumed in the original analysis and for the alternative scenarios identified in Task 3 if this is requested by the Oversight Panel.
4. Carcinogenic incidence risk will be estimated for each annual dose limit.

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**Deliverables:**

1. Meet with the Oversight Panel and present latest findings, address concerns, and discuss future direction.
2. A draft report will be delivered by September 8, 1999.
3. A final report will be delivered by November 8, 1999.

## Task 6. Protocols

1. Review and evaluate established soil sampling methodologies for application to RFETS.
2. Recommend a soil sampling protocol that addresses characterization sampling to determine that nature and extent of contamination before remedial efforts and verification sampling to assess remaining residual contamination after remediation.
3. Provide a review of the current methods of sampling and analysis at RFETS.
4. Conduct a literature review of soil sampling design based on statistical considerations and incorporate the information into the recommended sampling design.
5. Address quality assurance issues regarding data quality objectives, documentation, chain-of-custody, laboratory requirements, and data validation.

**Deliverables:**

1. Meet with the Oversight Panel and present latest findings, address concerns, and discuss future direction.
2. A draft report will be delivered by May 8, 1999.
3. A final report will be delivered by August 8, 1999.

## Task 7. Actinide Migration

1. Meet with the Actinide Migration Panel early in the project to review their current understanding and evidence of actinide migration at RFETS.
2. Based on the findings in (1), consider what other pathways may be relevant for evaluation of offsite exposures.
3. Evaluate what potential impact actinide migration will have on the soil action levels, given offsite does limits and water quality standards for offsite exposure may be more restrictive.
4. Identify data gaps that will impact future hydrologic studies of actinide migration from RFETS.

**Deliverables:**

1. Meet with the Oversight Panel and present latest findings, address concerns, and discuss future direction.
2. Meet with the Actinide Migration Panel, as needed or directed by Oversight Panel; summarize meeting in letter report to Oversight Panel.
3. Incorporate findings into final reports.

## Task 8. Public Interface

1. For the three broad public meetings held during this project, RAC scientists will attend these meetings and present information on the project.
2. In coordination with the Oversight Panel, RAC scientists will make themselves available to members of the public when they are in the area.

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3. RAC will attempt to answer questions that are asked during the course of the project. RAC will keep a record of questions asked by members of the public in order to track responses thoroughly and efficiently. This record will be made part of the final records of the project.

**Deliverables:**

1. RAC will deliver the record of questions asked during the course of the project to be made part of the final project record at the completion of the project.

### Task 9. Major Project Deliverables and Peer Review

1. RAC will deliver a final comprehensive report at the end of the project. The main body of the report will be directed to the level of the educated public and will summarize findings and recommendations. Four appendices will provide the technical details of the work. These appendices include: Appendix A Cleanup Levels at Other Sites; Appendix B Computer Models, Methodology, Input Assumptions, and Independent Calculation; Appendix C Sampling Protocol; and Appendix D Summary of Meetings with the Actinide Migration Panel.
2. Throughout the project, RAC will submit interim project reports for Peer Review as directed by the Oversight Panel. RAC will respond to questions, comments, or suggestions developed by the peer reviewers.
3. If deemed necessary, RAC will provide assistance to the Oversight Panel in preparing a separate summary report directed to members of the general public who are unfamiliar with the current proposed soil action levels. The responsibility for producing this summary report lies with the Oversight Panel.
4. RAC will prepare monthly or bimonthly milestone reports as indicated in Exhibit B of this contract which describe tasks accomplished in completion of milestones and make requests for compensation.

**Deliverables:**

1. Milestone reports outlining work accomplished and compensation requested will be delivered according to the schedule outlined in Exhibit B of this contract, Rate and Payment Schedule.
2. A draft comprehensive project report will be delivered by October 8, 1999.
3. A final comprehensive project report will be delivered by November 8, 1999.

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## Summary of Information Contained in Milestone Reports

A comprehensive report will be generated at the end of this project. The main body of the report will be written for the public and will summarize RAC's findings and recommendations. Appendices will provide the technical details the work.

### Milestone 1 (1/8/99)

- RAC will review the approaches to interpretation of data and results in simulation ("methodologies") and develop a discussion of these approaches for the panel. A presentation of RAC's findings will be made to the panel.
- RAC will provide a review of the existing procedures and protocols for sampling (part of Appendix C.)
- RAC will meet with the Actinide Migration Panel and provide a written summary of the meeting.
- RAC will attend the monthly panel meetings and provide summaries of the discussion points.

### Milestone 2 (2/8/99)

- RAC will provide a table summarizing soil action levels at other sites (part of Appendix A).
- RAC will provide a review of available computer models that may be used to calculate soil action levels (part of Appendix B).
- Results of a preliminary uncertainty analysis using the RESRAD computer code and the parameters used in the current SAL calculations will be provided (part of Appendix B).
- Sampling protocol based on statistical methods will be provided (part of Appendix C).
- RAC will attend the monthly panel meetings and provide summaries of the discussion points.

### Milestone 3 (4/8/99)

- Draft report of a review of soil action levels at other sites (Appendix A) will be submitted to the panel.
- Testing and analysis of candidate computer programs will be completed and a brief technical memorandum documenting findings will be provided.
- Probability distribution for parameters identified in Task 3a will be provided.
- Evaluation of quality assurance procedures for soil sampling will be provided and a draft report of Appendix C will be submitted to the panel.
- RAC will provide a review of other potentially important pathways of exposure based on its interaction with the Actinide Migration Panel (part of Appendix D).
- RAC will attend the monthly panel meetings and provide summaries of the discussion points.

### Milestone 4 (6/8/99)

- Final report of a review of soil action levels at other sites (Appendix A) will be submitted.
- Draft report documenting the acquisition, testing, and analysis of computer programs (part of Appendix B) will be submitted.
- A table of proposed exposure scenarios will be provided.
- Program setup to run Monte Carlo calculations using RESRAD will be completed.

- RAC will provide a review of other potential important pathways of exposure based on its interaction with the Actinide Migration Panel (Part of Appendix D).
- RAC will attend the monthly panel meetings and provide summaries of the discussion points.

**Milestone 5 (7/8/99)**

- Results of the Monte Carlo uncertainty analysis using RESRAD will be provided.
- Dose limits will be converted to carcinogenic risk and presented to the panel.
- Final report of sampling protocol procedures will be submitted to the panel.
- RAC will provide a review of data gaps that prohibit a detailed examination of offsite migration of actinides. The review will be based on RAC's interaction with the Actinide Migration Panel (Part of Appendix D).
- RAC will attend the monthly panel meetings and provide summaries of the discussion points.

**Milestone 6 (8/8/99)**

- Final report documenting the acquisition, testing, and analysis of computer programs (part of Appendix B) will be submitted.
- Draft report covering inputs and assumptions will be submitted (part of Appendix B).
- Preliminary SALs based on RAC's independent methodology will be provided.
- RAC will attend the monthly panel meetings and provide summaries of the discussion points.

**Milestone 7 (11/8/99)**

- Final report on inputs and assumptions will be submitted (part of Appendix B).
- Draft and final reports will be issued covering the independent calculation of the SALs and meetings with the Actinide Migration Panel (Appendix D).
- Draft and final comprehensive report will be provided.
- RAC will assist the panel in writing a summary document directed at the general public that will explain the results of the study.
- RAC will attend the monthly panel meetings and provide summaries of the discussion points.

**Project Deliverables**

A comprehensive report will be generated at the end of this project. The main body of the report will be directed to the level of the educated public and will summarize RAC's findings and recommendations. Four appendices will provide the technical details of RAC's work. The appendices will cover the following technical topics:

| | |
|---|---|
| Appendix A | Cleanup Levels at Other Sites |
| Appendix B | Computer Models, Methodology, Input Assumptions, and Independent Calculation |
| Appendix C | Sampling Protocol |
| Appendix D | Summary of Meetings |

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# EXHIBIT B

## Payment and Rate Schedule

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## Exhibit B
## Payment and Rate Schedule

| Milestone Report Number | Approximate Submittal Date | Approximate Hours Per Milestone | Approximate Payment Amount Per Milestone | Summary of Tasks/Subtasks in Each Milestone Report |
|---|---|---|---|---|
| Milestone Report 1 | 1/8/99 | 460 | $42,274.92 | 4a: Prepare presentation<br>6a: Review Existing Procedures/protocols<br>7a: Meet with Actinide Migration Panel<br>8: Interfacing and Responsibilities |
| Milestone Report 2 | 2/8/99 | 720 | $66,169.44 | 1a: Soil Action Levels at Other Sites<br>2a: Search and Acquisition<br>3a: Perform preliminary uncertainty analysis<br>6b: Determination of sampling protocol<br>8: Interfacing and Responsibilities |
| Milestone Report 3 | 4/8/99 | 1015 | $93,280.53 | 1b: Draft Report<br>2b: Testing and Analysis<br>3b: Develop parameter distributions<br>6c: Evaluation of QA methods<br>6d: Draft Report<br>7a: Meet with Actinide Migration Panel<br>8: Interfacing and Responsibilities |
| Milestone Report 4 | 6/8/99 | 1138 | $104,584.48 | 1b: Final Report<br>2c: Draft Report<br>3c: Evaluate exposure scenarios<br>3d: Program Setup for Monte Carlo<br>5a: Program Setup for Monte Carlo<br>5b: Calculation of SALs<br>7b: Evaluate other pathways<br>8: Interfacing and Responsibilities |
| Milestone Report 5 | 7/8/99 | 440 | $40,436.88 | 3e: Post process and interpret results<br>5c: Development of risk estimates<br>6d: Final Report<br>7a: Meet with Actinide Migration Panel<br>7c: Identify data gaps<br>8: Interfacing and Responsibilities |
| Milestone Report 6 | 8/8/99 | 400 | $36,760.80 | 2c: Final Report<br>3f: Draft Report<br>5d: Draft Report<br>8: Interfacing and Responsibilities |
| Milestone Report 7 | 11/8/99 | 340 | $31,250.95 | 3f: Final Report<br>5d: Final Report<br>7a: Meet with Actinide Migration Panel<br>7d: Draft and Final Reports<br>8: Interfacing and Responsibilities |
| Total | | 4,513hours | $414,758.00 | |

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**Direct Costs:** Direct costs for this contract are limited to travel costs and those costs associated with the production and distribution of the final project report. All direct costs will be invoiced monthly.

- Travel costs, including G&A and profit allowance, for the entire project are not to exceed $49,606. (This number includes direct travel costs for $43,128, G&A at 8% [$3,450], and profit at 6.5% [$3,029].)
- Costs associated with the production and distrubution of the final project report are not to exceed $5,636. (This number includes direct costs for $4,900, G&A at 8% [$392], and profit at 6.5% [$344].)

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**EXHIBIT C**

**Certificate of Completion**

# CONTRACT COMPLETION CERTIFICATE

TO: ROCKY FLATS CITIZENS ADVISORY BOARD (RFCAB)

FROM: ______________________________________
(Contractor)

INVOICE REFERENCE NUMBER: ______________________________________

PERIOD OF TIME COVERED BY INVOICE: ______________________________________

DATE OF THIS CERTIFICATE: ______________________________________

This Contract Completion Certificate ("Certificate") is made by Contractor in regard to the contract between RFCAB and Contractor, dated ________ __, 199_ ("Contract"). This Certificate is submitted by Contractor in connection with Contractor's invoice referenced above and in order to induce RFCAB to make to the Contractor a progress payment. To this end, Contractor hereby certifies, represents, warrants and covenants as follows:

1. Other than as set forth in writing and attached hereto and marked "Exhibit 1," Contractor is aware of no claim, dispute, circumstance or fact which Contractor asserts gives rise to an entitlement to compensation beyond that stated in the Contract or to an extension of time for Contractor's performance of the Contract. If Contractor is aware of no such claim, dispute, circumstance or fact, Exhibit 1 shall state "None." If no such claim, dispute, circumstance or fact is set forth in Exhibit 1, any such claim, dispute, circumstance or fact is hereby waived by Contractor.

2. Attached hereto and marked "Exhibit 2" is a description, in detail sufficient for independent verification, of the work performed, services rendered and items delivered which are the subjects of the referenced invoice.

3. Contractor certifies that the work and services performed have been performed in a prudent manner and in compliance with the Contract, that all necessary items for the performance of the Contract have been supplied and that Contractor has unencumbered title to those items.

4. Contractor reaffirms that it is able to and will perform all aspects of the Contract and, except as noted in Exhibit 1, that it can and shall do so for the Contract price and by the date stated in the Contract for completion.

5. Contractor specifically reaffirms its representations, warranties and covenants as set forth in the Contract and certifies that it is in compliance with all requirements, terms and conditions of the Contract.

6. The undersigned is duly authorized and empowered by Contractor to execute this Certificate.

______________________________________
[Type name of Contractor]

By:____________________________________
[Type name of authorized agent]

Its:___________________________________
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# PROPOSAL

## A Review of the Radionuclide Soil Action Levels at the Rocky Flats Environmental Technology Site

*Submitted To*
Rocky Flats Citizens Advisory Board
July 16, 1998

Name John E. Till, Ph.D. Title President

Signature J. E. Till Date July 16, 1998

"Setting the standard in environmental health"

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# INTRODUCTION

*Risk Assessment Corporation*[a] (*RAC*) submits this technical proposal to the Rocky Flats Citizens Advisory Board (RFCAB) in response to a Request for Proposal (RFP) to review the radionuclide soil action levels at the Rocky Flats Environmental Technology Site (RFETS). This technical proposal presents a 1-year plan for completing all of the tasks and subtasks outlined in the RFCAB's RFP. The *RAC* Team commits to executing all tasks and phases listed in the RFP in a comprehensive manner. With RFCAB's concurrence, the *RAC* Team plans to apply its own exceptional technical capabilities and innovative ways to address the issues raised in the RFP.

*RAC* is a group of scientists that work together as a research team. Although unique in our structure, *RAC* has proven to be a very successful and extremely efficient organization with a reputation that is internationally recognized. *RAC* has been working on dose reconstruction, environmental dosimetry, chemical risk assessment, and related disciplines for the past 20 years. Scientists on the *RAC* Team have worked closely together on complex research projects that have set a new standard for public and scientific credibility in public studies.

We believe this project has two major objectives: first, to respond to the tasks requested in the scope of work as developed by the RFCAB in a scientifically defensible manner; second, we believe that in carrying out these tasks, we have a responsibility to assist the Oversight Panel and the Citizen's Advisory Board in understanding the methods that are available to calculate acceptable levels of residual contamination in soil, the parameters that are used in these calculations, and the associated uncertainties. This second objective is critical for the Oversight Panel, the Citizen's Advisory Board, the U.S. Department of Energy (DOE), and the public to be effectively involved in the decision making process.

This proposal is presented in seven sections. Sections A and B highlight previous *RAC* corporate experience and the experience of the *RAC* Team. Section C provides our response to the statement of work. In Sections D, E, F, and G we provide the work schedule and respond to the Oversight Panel interface, peer review, and conflict of interest requirements. Section G provides our business proposal, including project management and the fees bid.

## A. PREVIOUS EXPERIENCE

*RAC* was founded in 1977 with the purpose of conducting research on the transport and fate of radionuclides and chemicals in the environment and assessing the associated health risks. Since its beginning, *RAC* has contributed significantly to the development and application of methods for estimating exposures from radionuclides and chemicals to the public and workers and quantifying the health risks and their uncertainties. *RAC* has also encouraged public participation in dose reconstruction studies and has developed innovations in the communication of exposure and risk information to the public.

*RAC* has gained a reputation for producing high-quality research involving fate and transport of radionuclides in the environment. A summary of the contractual details of past and current projects that *RAC* has been involved in is presented in Table 1. For those projects that are most relevant, a synopsis of the work follows.

[a] Formerly *Radiological Assessments Corporation.* Name change effective July, 1998.

## Fernald Dosimetry Reconstruction Project

The Fernald Dosimetry Reconstruction Project was conducted to estimate radiation doses and risks to people who lived near the Fernald (Ohio) Feed Materials Production Center (FMPC) during its years of operation from 1951 to 1988. *RAC* conducted the study for the Centers for Disease Control and Prevention (CDC), U.S. Department of Health and Human Services. The project was comprehensive with numerous supplementary investigations that added depth and breadth to the original work. *RAC* Team members worked closely with the CDC in adapting atmospheric dispersion and radiation dose models to obtain dose and risk estimates in a form compatible with a possible epidemiological (health effects) study. *RAC* interacted with the National Research Council's Committee on an Assessment of CDC Radiation Studies, which reviewed the source term and environmental transport and dose methodology reports.

The principal activity at the FMPC was uranium processing. Two large silos that store radium-containing waste materials are the source of radon and radon decay products released to the air. Particulate releases from the site were primarily uranium. This project estimated quantities of uranium, radon, radon decay products, and other radionuclides released to air, surface water, and groundwater, from both planned and unplanned releases. Exposure to airborne radionuclides was the most important exposure pathway for people who resided nearby. *RAC* carefully reviewed and described the radon source term, because early results indicated that radon emissions from the site contributed significantly to doses to the residents of the region.

The major findings on dose and risk for this project show that people who lived near the FMPC were exposed to the decay products of radon and to uranium, with radon decay products contributing most of the radiation dose. Nine exposure scenarios were developed to give a sense of the relationship between the doses and risks and various modes of exposure to the Fernald releases.

Several important pieces of work were produced in the course of the project that have advanced the state-of-the-art of environmental dosimetry and dose reconstruction. Each piece is summarized below.

***RAC* reconstructed the source terms instead of validating the site-generated source terms, as originally proposed.** The airborne release estimates were based on site measurements, normalized releases and process engineering principles. Airborne waste streams were typically treated prior to their release to the environment using either dust collectors (filters) or scrubbers (treatment systems employing liquids to remove particulate matter from gaseous waste streams). *RAC* investigated the efficiency of both of these methods, which varied greatly with the state of the technology at the time, system maintenance, and plant throughput. Relevant site-specific data were used as much as possible.

Four meteorological datasets were analyzed in selecting appropriate meteorological data for modeling the transport of airborne releases. The absence of site-specific meteorological information for early years of the facility's operation presented a serious problem for the completion of the dose reconstruction. Systematic onsite meteorological measurements had been made at the FMPC beginning in 1986. Therefore, *RAC* used the long-term Cincinnati airport record to estimate the uncertainty in applying the recent site data to the earlier period.

Particle size played an important part in the air transport and dosimetry modeling for uranium releases at Fernald. *RAC* made use of limited particle size measurements from stack emissions in the late 1980s to estimate distributions for use in the models. *RAC* found that particles from the dust collector releases were in the respirable range and, consequently, were the most important from the point of view of inhalation dosimetry. However, *RAC* calculated that scrubber effluents from Plant 2/3 and Plant 8 discharged reentrained particles of much larger size, which were removed from the airborne plume near the point of release.

Concern about offsite groundwater contamination had been evident at the FMPC since the early years. Radioactivity reached the groundwater from the FMPC by ground infiltration of uranium in a form similar to that in liquid discharges. Monitoring data first collected in the 1980s showed that three offsite wells were contaminated with uranium. For calculating radiation doses from drinking water from a contaminated well for times before the monitoring was done, *RAC* developed an empirical model to estimate the historical trend of uranium concentrations in the contaminated wells.

***RAC* developed exposure scenarios to communicate the final results of the study to the public.** To consider the features of a person's life, *RAC* developed exposure scenarios for nine hypothetical, but realistic residents of the FMPC area, for whom radiation dose and risk estimates could be made. Many people who lived near the FMPC were able to relate their own experiences to features in the nine scenarios developed in this study. The scenarios were not designed to include all conceivable lifestyles of residents of this region during the time of the FMPC operations, but they served as guides to a range of potential exposures to FMPC radionuclides and radiation of people in the area.

**Historic environmental measurements provided the proof or support for our model calculations.** Monitoring data from the FMPC were used for comparison with our model-calculated concentrations for both the air and water transport pathways, and to develop site-specific parameters for the models. This validation process is an integral part of a complete dose reconstruction. The results of the comparisons were generally quite good, allowing for the complexity of the processes that influence the results.

**Public issues and concerns were addressed at Fernald.** The two-way public interaction during the Fernald project was instrumental in locating additional sources of information from residents, site employees and others around the country who were carefully watching CDC's first dose reconstruction project. *RAC* willingly participated in this interaction, because we have always believed that scientific and public credibility in such a study are of equal importance. Members of a local citizens' group, called FRESH, attended all of our workshops and public meetings that were held about three times a year during the project. They asked probing questions, and met with *RAC* during their regular monthly meetings and informally on many occasions.

## Rocky Flats

Through a 1989 Agreement in Principle between the DOE and the State of Colorado, DOE provided the State with funding and technical support for health-related studies. The purpose of the Historical Public Exposures Studies on Rocky Flats is to identify potential health effects in residents in nearby communities who may have been exposed in the past to toxic chemicals and radioactive materials released from the Rocky Flats Plant. The Colorado Department of Public Health and Environment (CDPHE) first invited a national panel of experts to help design the health studies. Because of strong public concern about Rocky Flats contamination among the area residents following a Federal Bureau of Investigation raid of Rocky Flats in June 1989, the panel decided to stress public involvement. They also separated the research into two major phases conducted by two different contractors to enhance accountability and credibility.

Phase I of the study was performed by ChemRisk (a division of McLaren/Hart, Environmental Engineering). In Phase I, ChemRisk conducted an extensive investigation of past operations and releases from the Rocky Flats Plant. *RAC* was awarded the contract to conduct Phase II of the study, which is an in-depth investigation of the potential doses and risks to the public from historical releases from Rocky Flats. Recommendations for work to be performed in Phase II included

- A complete and systematic review of all classified documents related to Rocky Flats and a thorough re-evaluation of unclassified records identified in Phase I
- Detailed source term reconstruction of the major plutonium releases from the plant, including releases from fires in 1957 and 1969 and from an outdoor area storing drums of plutonium-contaminated solvents
- An independent evaluation of dose and risk from releases from the plant
- A site-specific evaluation of atmospheric transport models to identify the most appropriate models for routine releases and short-term events
- Derivation of uncertainty in the risk conversion factors for plutonium, using the latest models
- Evaluation of historical monitoring data for long-term trends in radioactivity in environmental media.
- More complete characterization of releases of radionuclides to surface water
- Recommendation of critical monitoring needs to help verify the findings of the study
- Technical support for public outreach.

To date, *RAC* has completed all but the independent evaluation of dose and risk. Completion of this project is scheduled for September of 1999. Completion of the tasks outlined above has required specific expertise in areas of source term reconstruction, multimedia environmental fate and transport modeling, environmental monitoring, dosimetery, data evaluation, and statistics. Several important pieces of work have been produced in the course of the project that have advanced the state-of-the-art of environmental dosimetry and dose reconstruction. Each piece is summarized below.

**Site-specific uncertainty factors were established for atmospheric transport models.** Five atmospheric models representing different levels of complexity were compared against sulfur hexafluoride tracer measurements taken at the Rocky Flats Environmental Technology site. The purpose of the comparison was twofold: (1) to establish which models performed best considering the Rocky Flats environment, and (2) to estimate the uncertainty in model predictions made at the site. Rocky Flats represents a complex terrain environment that is challenging to model with atmospheric transport models. *RAC*'s comparisons of model predications with observed tracer measurements made it possible to evaluate the relative performance of each model and to estimate the uncertainties inherent in model predictions made at the site.

**The uncertainty in age and sex dependent plutonium dose and risk factors were established.** The principal radionuclides of concern at Rocky Flats are the plutonium isotopes $^{239}Pu$ and $^{240}Pu$. Several national and international agencies have provided dose conversion factors and risk estimates for inhalation of plutonium, but few have explored the uncertainty associated with these factors. *RAC* estimated the uncertainty and the age and sex dependency in the factors for plutonium dose and risk. Our dosimetry research applied the contemporary biokinetic models to inhaled plutonium for a range of particle sizes. In estimating risk coefficients, we considered all relevant epidemiological studies on cancer induction resulting from exposure to radiation, and used weighting factors to estimate distributions of mortality and morbidity rates following exposure to radiation. Distributions of risk coefficients (cancer incidence risk per unit of inhaled plutonium) were derived that incorporated uncertainties from all sources.

**A thorough evaluation of the causes and consequences of plutonium fires in glove boxes was performed.** In September of 1957, a fire in one of the glove boxes at Rocky Flats resulted in failure of the filter system and release of a substantial amount of plutonium into the environment. A detailed investigation was conducted to determine (a) the quantity of plutonium in the filter and duct work that was susceptible to release, (b) the timing and sequence of events that led up to the release, and (c) the quantity of plutonium released. In every step of the process, uncertainty was estimated and propagated through to the final release estimate.

**Dust suspension models were applied and calibrated to predict transport of plutonium contaminated soils.** One of the largest sources for offsite releases at the Rocky Flats plant was the suspension of plutonium contaminated soil from an old drum storage area called the 903 Area. From 1964 to 1969, drums containing plutonium-contaminated cutting oil were stored on the 903 Area pad. Corrosion of these drums led to leakage of the cutting oil to the ground surface. Removal of these drums and subsequent remediation efforts, coupled with windstorm events, resulted in suspension and redistribution of the contaminated soil into a field east of the storage area. Our research has incorporated an integrated approach that combined environmental monitoring data, detailed meteorological data, suspension modeling, and atmospheric transport modeling to estimate releases from the 903 Area.

**Environmental monitoring data used for quantifying and validating effluent releases from the site were evaluated to provide greater confidence in the results.** One of the most important aspects of a dose reconstruction study is an evaluation of the environmental monitoring data. In the absence of useful source term data, environmental monitoring data can be used to estimate effluent releases. In addition, validation of model predictions is achieved through comparison of estimates with field observations. In order to provide independent judgment of the quality and usefulness of the data, *RAC* staff performed a detailed review of all environmental monitoring data collected at the site, insisting in many instances on obtaining the original records.

**Public issues and concerns were addressed.** Undoubtedly, public credibility in historic dose reconstruction studies is key to the success of a study. *RAC* has taken considerable time and effort beyond this project's contract specifications to address directly the concerns of the public, especially those of environmental groups who have been very active in the public affairs of Rocky Flats. From the beginning of the study, *RAC* has held special meetings with these groups to discuss their concerns. We have carefully reviewed hundreds of pages of their letters and memos and have provided written responses to them, copies of which are preserved in a number of large binders. *RAC* feels that this has been a crucial part of the work, although resolution of these issues has been time consuming. We have made a concerted effort throughout the project to respond not only to the concerns of the Health Advisory Panel but equally to the suggestions and concerns of the public. *RAC* firmly believes that successful interaction with the public must be carried out by the scientific research team.

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**Table 1. *RAC* Corporate Experience**

| Project Name | Sponsoring Agency | Sponsoring Program Official | Contract Number | Contract Type | Contract Amount | Period of Performance | Approximate labor hours |
|---|---|---|---|---|---|---|---|
| Fernald Dosimetry Reconstruction Project | CDC | Dr. James Smith 770-488-7040 | 200-90-0803 | Cost- plus-fixed-fee | $2,866,641 | 7/10/90 – 10/31/98 | 32,000 hours |
| LANL Independent Audit | Department of Justice | Beverly Schutte 202-616-3359 | DOJ File No.: 90-5-2-1749A Case Name: CCNS v DOE | Firm price, fixed fee | $300,000 | 5/1/97 – 12/31/98 | 3500 hours |
| Rocky Flats Nuclear Weapons Plant Dose Reconstruction Project: Phase II, Toxicity Assessment and Risk Characterization | Colorado Department of Public Health and the Environment | Dr. Norma Morin 303-692-2645 | CDPHE #95-1451 | Cost-plus-fixed-fee | $5,524,004 | 10/1/92 – 9/30/99 | 50,000 hours |
| SRS Dose Reconstruction, Phase I | CDC | Dr. James Smith 770-488-7040 | 200-92-0549 | Cost-plus-fixed-fee | $1,780,000 | 10/92 – 6/95 | 23,000 hours |
| SRS Dose Reconstruction, Phase II | CDC | Dr. James Smith 770-488-7040 | 200-95-0904 | Cost-plus-fixed-fee | $1,476,787 | 9/20/95 – 9/30/98 | 19,000 hours |
| CDC Task Orders | CDC | Dr. James Smith 770-488-7040 | 200-95-0927 | Cost-plus-fixed-fee | $1,568,718 | 5/7/96 – 9/30/99 | 18,300 hours |
| Utah Fallout Studies: (1) A Cohort Study of Thyroid Disease and Radioactive Fallout from the Nevada Test Site (NTS) and (2) A Case-Control Study of Leukemia Deaths in Utah (1952-81) and Exposure to Radioactive Fallout from the NTS | National Cancer Institute | Dr. Walter Stevens, Dean, U of Utah Medical School 801-581-6436 | NCI #NO1-CO-23917 | | $7,000,000 | January 1986—May 1992 | 53,000 hours |

## B. PERSONNEL

### *Curricula Vitae* of Key Personnel

**JOHN E. TILL, PH.D.**
**President, *RISK ASSESSMENT CORPORATION***

[redacted]

### Education

- Ph.D., Nuclear Engineering, Georgia Institute of Technology, Atlanta, Georgia, [redacted]
- M.S., Health Physics, Colorado State University, Fort Collins, Colorado, [redacted]
- U.S. Naval Nuclear Propulsion Program, Submarine Force. Three schools consisting of Nuclear Power School, Mare Island, California; S5G Prototype NPTU, Idaho Falls, Idaho; Submarine School, Groton, Connecticut
- B.S., Engineering (with distinction), U.S. Naval Academy, Annapolis, Maryland, [redacted]

### Professional Experience

***Risk Assessment Corporation***
*President*, Neeses, South Carolina (1977–present)

Owner and president of *Risk Assessment Corporation, Inc.*, which focuses on the analysis of dose from radionuclides and chemicals released to the environment. Completing research contracts for the Environmental Protection Agency, Chem-Nuclear Corporation, Oak Ridge National Laboratory, Battelle Pacific Northwest Laboratory, Du Pont Company, University of Utah, Centers for Disease Control and Prevention, Colorado Department of Public Health and Environment, and Department of Justice among others.

**Embeford Farm**
*President/Owner (1200-acre family farm)*, Neeses, South Carolina (1977–present)

**Oak Ridge National Laboratory**
*Research Associate*, Oak Ridge Tennessee (1974–1977)

Conducted assessments of radiological impacts around nuclear facilities, performed studies to evaluate environmental impact of advanced fast reactor fuels, and developed and improved models to evaluate radionuclide releases to the environment.

**Consultant, Allied-General Nuclear Services**
*Consultant*, Barnwell, South Carolina (1973–1974)

Developed an in-plant health physics training program and wrote the *Safety and Environmental Control Department Policy Manual* for a nuclear fuel reprocessing plant being constructed by Allied-General Nuclear Services.

**Georgia Institute of Technology**
*Research Assistant*, Atlanta, Georgia (1973–1974)

Provided research and teaching support in the School of Nuclear Engineering.

**Colorado State University**
*Research Assistant*, Fort Collins, Colorado (1971–1972)

Developed and tested an instrument that rapidly measures working level exposure of radon daughters.

**U.S. Navy, Nuclear Submarine Force**
*Officer* (1967–1971)

Became qualified to operate an S5W nuclear reactor and qualified in submarines. Other responsibilities included reactor control officer, electrical division officer, and operations officer.

## Special Awards and Positions

- Elected Member, International Commission on Radiological Protection, Committee 4, 1997.
- Recipient of the E.O. Lawrence Award in the field of environmental science and technology. Award is presented to several outstanding scientists each year following nominations sought from over 2000 organizations, 1995.
- Adjunct Professor of Physics, Emory University, Atlanta, Georgia, 1985–1995.

## Professional Activities

### Special Appointments

- Member Scientific Review Group, U.S. Department of Energy, Joint Coordinating Committee for Radiation Effects Research, 1995–1997.
- Consultant to U.S. Nuclear Regulatory Commission, Advisory Committee on Reactor Safeguards, 1986–1990.
- Member, Illinois Department of Nuclear Safety Technical Advisory Panel on Low-Level Waste Disposal Systems, 1986–1989.

### Committee Memberships and Elected Offices

- Member, National Council on Radiation Protection and Measurements, 1984–present.
- Vice President for Environmental Issues, National Council on Radiation Protection and Measurements, 1996–present.
- Member, International Commission on Radiological Protection Committee on Chronic Exposures, 1997–present.
- Member, International Commission on Radiological Protection Working Party on Controllable Doses, 1997–present
- Chairman, Scientific Committee 64, Risk Assessment, National Council on Radiation Protection and Measurements, 1995–present.
- Chairman, Scientific Committee 64-19 on Dose Reconstruction, National Council on Radiation Protection and Measurements, 1994–present.
- Member, "Mortality of Military Personnel Present at Atmospheric Tests of Nuclear Weapons," National Academy of Sciences, 1993–present.
- Chairman, Dosimetry Working Group, "Mortality of Military Personnel Present at Atmospheric Tests of Nuclear weapons," National Academy of Sciences, 1993–1995.
- Chairman, Task Group Six on Developing Screening Models for Evaluating Releases of Radionuclides to the Environment, National Council on Radiation Protection and Measurements Scientific Committee 64, 1982–1994.

- Board of Directors, National Council on Radiation Protection and Measurements, 1989–1994.
- Member, Nominating Committee, National Council on Radiation Protection and Measurements, 1988–1993.
- Member, Health Effects and Defense Waste Working Group, Office of Technology Assessment, U.S. Congress, 1990.
- Member, Department of Energy "Joint Coordinating Committee on Radiation Effects Research," 1995–1997.

**Selected Relevant Publications**

**Till, J.E.** and M.L. Frank. 1977. "Bioaccumulation, Distribution, and Dose of $^{241}$Am, $^{244}$Cm, and $^{238}$Pu in Developing Fish Embryos." *Proc. IVth International IRPA Congress.* Paris, France, April 24–30. pp. 645–648.

**Till, J.E.** 1978. "The Effect of Chronic Exposure to $^{238}$Pu(IV) Citrate on the Embryonic Development of Carp and Fathead Minnow Eggs." *Health Physics* 34 (4).

**Till, J.E.** and H.R. Meyer, eds. 1983. *Radiological Assessment: A Textbook on Environmental Dose Analysis.* NUREG/CR-3332, ORNL-5968. U.S. Nuclear Regulatory Commission.

**Till, J.E.** and W.L. Templeton (technical editors and task group leaders). 1984. *Radiological Assessment: Predicting the Transport, Bioaccumulation, and Intake by Man of Radionuclides Released to the Environment.* NCRP Report No. 76.

**Till, J.E.** and K.R. Meyer. 1986. *A Review of the Basis of Risk Calculations for Exposure to Chemicals and Radionuclides and Recommendations Regarding the Acceptability of Combining Risk Estimates. RAC* Report No. 5/86. July 18.

**Till, J.E.** and R.E. Moore. 1988. "A Pathway Analysis Approach for Determining Acceptable Levels of Contamination of Radionuclides in Soil." *Health Physics* 55 (3).

**Till, J.E.**, R.E. Moore, and G.G. Killough. 1989. *DECOM™: An All-Pathway Approach for Determining Acceptable Levels of Radionuclides in Soil.* Radiological Assessments Corporation Report. April 25.

Simon, S.L., **J.E. Till**, R.D. Lloyd, R. Kerber, D.C. Thomas, S. Preston-Martin, and W. Stevens. 1995. "The Utah Leukemia Case-Control Study: Dosimetry Methodology and Results." *Health Physics* 68 (4).

Templeton, W.L., **J.E. Till** (Co-Chairmen), D.A. Baker, B.G. Blaylock, R.B. Codell, F.O. Hoffman, C.W. Miller, and Y. Onishi. 1995. *Screening Models for Releases of Radionuclides to Air, Surface Water, and Ground Water.* NCRP Report No. 123 (Vols. I and II). National Council on Radiation Protection and Measurements, Bethesda, Maryland.

**Till, J.E.**. 1995. "Building Credibility in Public Studies." *American Scientist* 83 (5). Magazine of Sigma Xi. The Scientific Research Society.

**Till, J.E.** 1998. Keynote Address. *Proceedings of the First Annual University of Washington Conference on the Ecological, Community and Occupational Health Issues at Hanford, December 3. 1997.* (in press)

## GEORGE G. KILLOUGH
## HENDECAGON CORPORATION

[redacted]

### Education

- M.A., Mathematics, University of Tennessee, Knoxville, Tennessee, [redacted]
- A.B., Mathematics Education, University of North Carolina, Chapel Hill, North Carolina, [redacted]

### Professional Experience

**Hendecagon Corporation**

*President and Technical Director,* Oak Ridge, Tennessee (1990–present)

Consultant to *Radiological Assessments Corporation* for the Fernald and the Savannah River Site dose reconstruction projects, sponsored by the Centers for Disease Control and Prevention, and the Rocky Flats dose reconstruction project, sponsored by the Colorado Department of Public Health and Environment.

*Founder and CEO,* Oak Ridge, Tennessee (July 1987–1990)

Founded Hendecagon Corporation, a small company specializing in innovative applications of mathematical and statistical methods to environmental assessments of radiological and chemical pollutants. Participated in developing the computer codes DECOM (for radionuclides) and DECHEM (for chemicals) to model contaminant transport in soils, groundwater, and the food chain. Provided systems analysis and programming for MICROAIRDOS Version 2.0.

**Oak Ridge National Laboratory**

*Research Staff Member,* Environmental Sciences Division and Health and Safety Research Division (1974–July 1987)

Co-edited a major radiological assessment methodology handbook. Provided technical assistance to Liquid Metal Fast Breeder Reactor and High Temperature Gas Cooled Reactor programs by performing research in the environmental transport and dosimetry of $^{14}C$ released from these fuel cycles. Led the development of the INREM II internal dose methodology for radionuclides released from the light-water reactor fuel cycle; INREM II became the dosimetry basis of the U.S. Environmental Protection Agency RADRISK methodology. Led the development of the RAGTIME dynamic food-chain model for radioactive pollutants in agricultural systems. Led the modification of the TACT III accident evaluation code for the U.S. Nuclear Regulatory Commission. Participated extensively in National Science Foundation- and U.S. Department of Energy-sponsored basic research projects in modeling the global carbon cycle for prediction of the greenhouse effect. Developed an age-dependent approach to iodine dose reconstruction for application to clinical histories of $^{131}I$ exposure for the U.S. Food and Drug Administration. Developed a dynamic global transport model for tritium released to the environment (TRICYCLE). After retiring from the Laboratory, developed the RAGTIME87 dynamic food-chain model (a reimplementation of the earlier RAGTIME model) and collaborated in the model's participation in an international validation exercise initiated by the Swedish National Institute for Radiation Protection.

**Consultant**
Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, Tennessee (1972–1973)

Developed the INDOS codes for implementation of ICRP Publication 10 internal dose methodology.

**East Tennessee State University**
*Assistant and Associate Professor of Mathematics*, East Tennessee State University, Johnson City, Tennessee (1966–1974)

Conducted courses in analysis, linear algebra, differential equations, numerical methods, and computer science. Formulated curricula and programs for a proposed department of computer science, which was subsequently established. Organized and conducted computer orientation seminars for faculty members. Supervised numerous master's theses in mathematics and participated in the doctoral program of the College of Education.

**University of Tennessee at Knoxville**
*Instructor in Mathematics* (1964–1966)

Taught courses in calculus, probability theory, ordinary and partial differential equations, complex variable, and calculus of finite differences for students of science and engineering.

**Consultant**

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, Tennessee (1964–1966)

**Selected Relevant Publications**

**Killough, G.G.** and L.R. McKay, eds. 1976. *A Methodology for Calculating Radiation Doses from Radioactivity Released to the Environment.* ORNL-4992. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Walsh, P.J. **G.G. Killough**, and P.S. Rohwer. 1978. "Composite Hazard Index for Assessing Limiting Exposures to Environmental Pollutants: Formulation and Derivation." *Environmental Science and Technology* 12: 799–802.

Bondietti, E.A., J.R. Trabalka, C.T. Garten, and **G.G. Killough**. 1979. "Biogeochemistry of Actinides: A Nuclear Fuel Cycle Perspective." In *Radioactive Waste in Geologic Storage.* ACS Symposium Series 100. Edited by S. Fried. American Chemical Society, Washington, D.C.

**Killough, G.G.** 1980. "A Dynamic Model for Estimating Radiation Dose to the World Population from Releases of $^{14}C$ to the Atmosphere." *Health Physics* 38: 169–200.

Pleasant, J.C., L.M. McDowell-Boyer, and **G.G. Killough**. 1980. *RAGTIME: A FORTRAN IV Implementation of a Time-dependent Model for Radionuclides in Agricultural Systems—First Progress Report.* NUREG/CR-1196, ORNL/NUREG/TM-371. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

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**Killough, G.G.** and K.F. Eckerman. 1983. "Internal Dosimetry." Chapter 7 in *Radiological Assessment: A Textbook on Environmental Dose Analysis*. NUREG/CR-3332, ORNL-5968. Edited by J.E. Till and H.R. Meyer. U.S. Nuclear Regulatory Commission, Washington, D.C.

**Killough, G.G.** and D.E. Dunning, Jr. 1987. "Analysis of Uncertainties in CRAC2 Calculations: The Inhalation Pathway." In *Uncertainty in Risk Assessment, Risk Management, and Decision Making*. Edited by V.T. Covello, L.B. Lave, A. Moghissi, and V.R.R. Uppuluri. New York: Plenum Press. 287–303

**Killough, G.G.**, M.J. Case, K.R. Meyer, R.E. Moore, J.F. Rogers, S.K. Rope, D.W. Schmidt, B. Shleien, J.E. Till, and P.G. Voillequé. 1993. *The Fernald Dosimetry Reconstruction Project—Task 4: Environmental Pathways—Models and Validation*. *RAC* Report No. CDC-3. Radiological Assessments Corporation, Neeses, South Carolina.

**Killough, G.G.**, M.J. Case, K.R. Meyer, R.E. Moore, S.K. Rope, D.W. Schmidt, B. Shleien, W.K. Sinclair, P.G. Voillequé, and J.E. Till. 1996. *Task 6: Radiation Doses and Risk to Residents from FMPC Operations from 1951–1988, Volume I and Volume II—The Fernald Dosimetry Reconstruction Project*. *RAC* Report No. 4-CDC-Fernald-1966-DRAFT. Radiological Assessments Corporation, Neeses, South Carolina.

Rogers, J.F. and **G.G. Killough**. 1997. "Historical Dose Reconstruction Project: Estimating the Population at Risk." *Health Physics* 72 (2): 186–194.

## ARTHUR S. ROOD
## K-SPAR SCIENTIFIC CONSULTING INC.

[redacted]

### Education

- M.S., Health Physics, Colorado State University, Fort Collins, Colorado, [redacted]
- B.S., Geology, Mesa State College, Grand Junction, Colorado, [redacted]
- A.A., Mathematics, Santa Monica College, Santa Monica, California, [redacted]

### Professional Experience

**K-Spar Scientific Consulting**

*President*, Rigby, Idaho (July 1994–present)

Research, develop, and apply state-of-the-art techniques for environmental dose reconstruction at U.S. Department of Energy (DOE) field offices at Rocky Flats, Colorado, and Savannah River, South Carolina. Research includes verifying and validating air dispersion models, developing models to predict suspension and transport of contaminated soil, and performing Monte Carlo calculations of lifetime cancer incidence risk for representative members of the public exposed to contaminants released from the facilities.

**Lockheed Martin Idaho Technologies Company**

*Advisory Engineer/Scientist*, Idaho Falls, Idaho (part time, October 1994–present)

Research, develop, and apply state-of-the-art techniques for assessing multimedia environmental transport and impacts associated with release of radioactive material and hazardous chemicals. Specific modeling expertise includes chronic and accident air dispersion, food-chain transport, groundwater flow and transport, dose and risk assessment, thermodynamic chemical vapor models, and first order kinetic models. Recent efforts have focused on low-level waste performance assessment.

Provide lead technical guidance and funding management for Idaho National Engineering and Environmental Laboratory (INEEL) and DOE-wide programs requiring complex environmental assessments and safety analyses. Provide technical guidance for an international study on uncertainty estimates in reactor consequence code evaluation. Assist the National Low-Level Waste program in providing technical assistance to waste compact states.

Instructor for the University of Idaho graduate-level course INTER 504, *Environmental Modeling,* from 1991 to present.

Principal Investigator for a national survey of naturally occurring radioactive material (NORM) in oil and gas production equipment. Member of the Health Physics Society/American National Standards Institute working group on NORM.

**EG&G Idaho, Inc.**

*Senior Scientist,* Idaho Falls, Idaho (May 1990–May 1994)

*Scientific Specialist*, Idaho Falls, Idaho (May 1994–October 1994)

Principal investigator for researching, developing, and applying state-of-the-art techniques for assessing environmental transport and impacts associated with release of radioactive material and hazardous chemicals. Specific modeling expertise included chronic and accident air dispersion, food-chain transport, groundwater flow and transport, dose and risk assessment, thermodynamic chemical vapor models, and first order kinetic models. Received certified training in GENII and CAP-88 radiological assessment codes; PORFLO-3 groundwater flow and transport code; and ISC, SCREEN, and INPUFF air quality models.

Provided lead technical guidance and funding management for INEEL and DOE-wide programs requiring complex environmental assessments and safety analyses. Developed groundwater transport models and computer codes (GWSCREEN) for assessment of Comprehensive Environmental Response, Compensation, and Liability Act sites and performance assessment of low-level waste disposal facilities at the INEEL. Performed calculations and modeling for the groundwater modeling and dose assessment section of the *Radioactive Waste Management Complex Low-Level Waste Radiological Performance Assessment* for the INEEL. Co-author of the food-chain model (COMIDA) for the MAACS reactor consequence code, an internationally recognized reactor accident assessment code.

Participated in four AIRDOS/CAP-88 radiological assessment courses for another DOE laboratory, INEEL contractor, and State personnel. Conducted performance. assessment workshops and provided technical assistance to the low-level waste compact states for the National Low-Level Waste Management Program.

**UNC Geotech**

*Staff Scientist*, Grand Junction, Colorado (August 1989–May 1990)

Performed indoor radon assessments and developed instrumentation to measure radon progeny. Conducted quality control experiments of radon measuring devices and wrote software for data acquisition systems and computer controlled instrumentation.

**EG&G Idaho, Inc.**

*Scientist-Researcher*, Idaho Falls, Idaho (September 1987–May 1990)

Developed and applied state-of-the-art techniques to assess the environmental transport and impacts associated with release of radioactive material and hazardous chemicals.

**Oak Ridge National Laboratory**

*Senior Health Physics Technician*, Grand Junction, Colorado (November 1984–September 1986)

Coordinated gamma spectroscopy laboratory for gamma spectral analysis of soil samples contaminated with uranium mill tailings. Wrote and implemented spectral analysis algorithms, multichannel analyzer control programs, and data base software.

**Selected Relevant Publications**

**Rood, A.S.** 1988. *Environmental Transport Concentration Factors for the FUSECRAC Fusion Reactor Safety Code.* EGG-ESE-8033. Idaho National Engineering Laboratory. May.

Walton, J.C., **A.S. Rood**, R.G. Baca, and M.D. Otis. 1989. "Model for Estimation of Chlorinated Solvent Releases from Waste Disposal Sites." *Journal of Hazardous Materials* 21: 15–34.

**Rood, A.S.**, R.C. Arnett, and J. Barraclough. 1989. *Contaminant Transport in the Snake River Plain Aquifer: Phase 1, Part 1: Simple Analytical Model of Individual Plumes.* EGG-ER-8623. Idaho National Engineering Laboratory. May.

**Rood, A.S.** and M.L. Abbott. 1991. *Comparison of Dose and Dose-rate Conversion Factors from the Soviet Union, United Kingdom, U.S. Department of Energy, and the Idaho National Engineering Laboratory Fusion Safety Program.* EGG-FSP-9865. Idaho National Engineering Laboratory. December.

Abbott, M.L. and **A.S. Rood.** 1994. "COMIDA: A Radionuclide Food-Chain Model for Acute Fallout Deposition." *Health Physics* 66 (1): 17–29.

Nguyen, H.D., S. Paik, and **A.S. Rood.** 1994. "Effects of Thermally Generated Convection on the Migration of Radionuclides in Saturated Geologic Formations." *International Journal Engineering Science* 32 (10): 1605–1614.

**Rood, A.S.** 1994. "GWSCREEN: A Model for Assessment of the Groundwater Pathway from Surface or Buried Contamination." *The Environmental Professional* 16 (3): 196–210.

**Rood, A.S.** 1997. *Performance Evaluation of Atmospheric Transport Models. RAC* Report No. 3-CDPHE-RFP-1996. *Radiological Assessments Corporation.* September.

**Rood, A.S.** 1997. *Estimated Exposure and Lifetime Cancer Incidence Risk from Routine Plutonium Releases at the Rocky Flats Plant.* 08-CDPHE-RFP-1997. *Radiological Assessments Corporation.*

**Rood, A.S.** G.J. White, and D.T. Kendrick. 1998. "Measurement of $^{222}$Rn Flux, $^{222}$Rn Emanation, and $^{226}$Ra Concentration from Injection Well Pipe Scale." *Health Physics* (in press).

**DAVID J. THORNE, CHP**
**CONSULTANT**

[redacted]

**Education**

- M.S., Health Physics, Colorado State University, Fort Collins, Colorado, [redacted]
- B.S., Geology, Mesa State College, Grand Junction, Colorado, [redacted]

## Professional Experience

**Consultant**

Grand Junction, Colorado (1997–present)

Technical consultant and reviewer for the *Yucca Mountain High Level Waste Repository Performance Assessment*. Performed computer programming, model testing, and documentation of the Total Performance Assessment (TPA-3) computer model.

Consultant for U.S. Department of Energy's Grand Junction Office. Provided assessments of residual contamination in buildings using the RESRAD-BUILD computer model. Report was submitted to DOE headquarters for consideration of supplemental standards. Performed atmospheric transport modeling for accident scenarios using the HOTSPOT and EPI-Code computer models for radionuclides and chemicals. Developed chemical engineering mass balance equations and mixing tank model calculations. Work performed to support the Safety Analysis Report for the Mixed-Waste Treatment Research Project.

Provided consulting services to Martin Marietta Energy Systems. Project included groundwater flow and transport modeling to determine the potential impacts from various volatile organic compounds for the National Guard site in Tucson, Arizona.

Developed risk assessment based remediation standards for Union Carbide Corporation's Gas Hills, Wyoming, and Uravan, Colorado, uranium mill processing sites. Work performed using the RESRAD computer code and site-specific data. Involved in the database design for radionuclide soil samples that required development for easy analysis and query of sample results from large data sets. Performed statistics based analyses for the determination of background soil concentrations of radionuclides and metals.

Provided support to the South West Research Institute for the performance assessment of depleted uranium at the Jefferson Proving Grounds. Project involved applying the RESRAD and MEPAS computer models for the assessment of remedial alternatives.

**Portage Environmental Inc.**

*Environmental Scientist/Senior Health Physicist,* Grand Junction, Colorado (1996–1997)

Lead scientist for the Pit 9 mixed waste treatment project at the Idaho National Engineering Laboratory. Responsible for atmospheric dispersion modeling studies in support of Permit to Construct applications, Prevention of Significant Deterioration analysis, and visibility impact analysis on a Class I National Park from mixed waste treatment facility operations. Responsibilities included computer code testing for radionuclide migration studies, analysis of performance assessment objectives, pathways analysis, and dose assessment.

**MSE, Inc.**

*Senior Health Physicist,* Grand Junction, Colorado (1994–1996)

Developed radiological risk assessments for remedial investigations and feasibility studies (RI/FSs). Conducted groundwater and atmospheric dispersion model studies in support of RI/FS investigations at the Idaho National Engineering Laboratory. Developed industrial hygiene procedures, including radio-particulate monitoring, radon daughter monitoring using the modified Kusnetz method, counting system calibration, and counting system operation for a prime U.S. Department of Energy contractor. Prepared analysis of potential heat and gas generation from transuranic waste slated for disposal at the Waste Isolation Pilot Plant.

**Martin Marietta Energy Systems, Inc.**

*Research Associate III,* Grand Junction, Colorado (1990–1994)

Developed computer models to simulate the transport of radionuclides from a low-level radioactive waste disposal site located at the Nevada Test Site. Conducted atmospheric, groundwater, and ecosystem transport and dose assessment studies for waste disposal and environmental restoration activities. Served as a research participant in the International Atomic Energy Agency's NSARS program on the environmental impacts of radioactive waste disposal. Prepared performance assessments for low-level radioactive waste disposal facilities located at the Nevada Test Site and the Savannah River Site. Developed the RIVER-RAD computer model to assist scientists with surface water flow and transport modeling studies.

**UNC Geotech, Inc.**

*Senior Health Physicist,* Grand Junction, Colorado (1990)

Designed and implemented an internal dosimetry program for environmental restoration personnel. Assisted in developing an atmospheric dispersion modeling study for the U.S. Department of Energy's Grand Junction Projects Office. Provided health and safety support to the U.S. Department of Energy's Grand Junction Office.

**EG&G Idaho, Inc.**

*Scientist,* Idaho Falls, Idaho (1988–1990)

Provided air quality modeling support to various Idaho National Engineering Laboratory environmental programs using the AIRDOS-EPA and ISC computer codes. Prepared radiological human health risk assessments for Idaho National Engineering Laboratory projects involving U.S. Environmental Protection Agency compliance. Conducted a study on the groundwater transport and health risk associated with dioxin in the environment.

### Professional Certifications and Memberships

- Certified Health Physicist (American Board of Health Physics)
- Member of the American Academy of Health Physics
- Plenary member of the Health Physics Society

### Selected Relevant Publications

**Thorne, D.J.** and J.E. Johnson. 1988. "I-131 in Milk Resulting from Nuclear Medicine Use." Colorado Rocky Mountain Chapter of the Health Physics Society, Colorado State University, Fort Collins, Colorado.

**Thorne, D.J.** and A.S. Rood. 1990. "Contaminant Fate and Effects in Ground and Surface Water at a Remediated Dioxin Site." *Hazardous Materials Control* 3(1): 57–61.

**Thorne, D.J.**, L.M. McDowell-Boyer, E.K. Roemer, and C.A. Little. 1991. "Results for Test Case 1 on the Safety Assessment of Near-Surface Radioactive Waste Disposal Facilities." First Coordinated Research Program Meeting of the International Atomic Energy Agency (NSARS), Vienna, Austria, July 4.

**Thorne, D.J.**, L.M. McDowell-Boyer, D.K. Halford, E.K. Roemer, and L.R. Lesperance. 1991. *Preliminary Performance Assessment of Low-Level Radioactive Waste Disposal at the Nevada Test Site in Subsidence Craters U3ah and U3at.* Oak Ridge National Laboratory.

McDowell-Boyer. L.M. and **D.J. Thorne**. 1992. "Long-Term Uncertainty in Radiological Performance Assessments of Low-Level Waste Facilities at the Savannah River Site."

Eighth Meeting of the International Radiation Protection Association Congress, Montreal, Canada, May 22.

**Thorne, D.J.**, P.M. Kearl, and L.M. McDowell-Boyer. 1992. "Results of Test Case 2A on the Safety Assessment of Near-Surface Radioactive Waste Disposal Facilities." Second Coordinated Research Meeting of the International Atomic Energy Agency (NSARS), Augusta, Georgia, November 20.

Hetrick, D.M., L.M. McDowell-Boyer, A.L. Sjoreen, **D.J. Thorne**, and M.R. Patterson. 1992. *RIVER-RAD: A Computer Code for Simulating the Transport of Radionuclides in Rivers.* ORNL/TM-21169. Oak Ridge National Laboratory.

**Thorne, D.J.**, L.M. McDowell-Boyer, D.C. Kocher, E.K. Roemer, and C.A. Little. 1993. *ORNL Results for Test Case 1 of the International Atomic Energy Agency's Research Program on the Safety Assessment of Near-Surface Radioactive Waste Disposal Facilities.* ORNL/TM-12101. Oak Ridge National Laboratory.

Morris, R., J. Warga, and **D. Thorne**. 1997. "Use of the RESRAD-BUILD Computer Code for Supplemental Standards to Reduce the Cost of D&D at the DOE Grand Junction Projects Office: A Case Study." Submitted for presentation at the 1997 American Nuclear Society annual meeting.

## Biographies of Technical Support Staff

### HELEN A. GROGAN, PH.D.
### CASCADE SCIENTIFIC, INC.

- Ph.D., Imperial College of Science and Technology, [redacted]
- B.Sc., Honors in Botany, Imperial College of Science and Technology, University of London, [redacted]
- GCE 'A' Levels, Solihull VIth Form College, Solihull, United Kingdom, [redacted]
- GCE 'O' Levels, Alderbrook Comprehensive, Solihull, United Kingdom, [redacted]

Dr. Helen A. Grogan graduated from Imperial College of Science and Technology, University of London in [redacted] with an Honors degree in life sciences. In [redacted] she was awarded a doctorate degree from the University of London. Dr. Grogan began working in Switzerland at the Paul Scherrer Institute (formerly the Swiss Federal Institute for Reactor Research) in [redacted] where she was responsible for the biosphere modeling of the safety assessment of high-level waste and low- and intermediate-level waste repositories. She participated in BIOMOVS, an international cooperative effort to test models that quantify the transfer and accumulation of radionuclides and other trace substances in the environment. Dr. Grogan also helped develop an approach for modeling the impact of microorganisms on the performance of a waste repository.

In 1989, Dr. Grogan began working for Intera as a senior staff consultant. She worked on a wide range of projects concerned with assessing the environmental impact of radioactive and nonradioactive hazardous wastes. She provided technical assistance to Nagra (Swiss National Cooperative for the Disposal of Radioactive Waste) to coordinate and execute safety assessments for high-level waste and low- and intermediate-level waste disposal. Dr. Grogan also continued her close involvement with BIOMOVS

In 1992, Dr. Grogan moved to the United States where she worked as an independent consultant before establishing Cascade Scientific, Inc. Her work currently focuses on several dose reconstruction projects that are studying past releases of radioactive and nonradioactive materials. Her work has emphasized quantifying the cancer risk and its uncertainty following exposure to plutonium from inhalation.

## H. ROBERT MEYER, PH.D.
## KEYSTONE SCIENTIFIC, INC.

- Ph.D., Radiation Biology, Colorado State University, Fort Collins, Colorado, [redacted]
- M.S., Health Physics, Colorado State University, Fort Collins, Colorado, [redacted]
- U.S. Navy Officer Candidate School, Newport, Rhode Island, [redacted]
- B.A., Physics, Saint Olaf College, Northfield, Minnesota, [redacted]

Following graduation from Saint Olaf College with a bachelor's degree in physics, Dr. Meyer served in the U.S. Navy for three years as a line officer. He received his master of science and doctorate degrees in health physics and radiation biology from Colorado State University in [redacted] Dr. Meyer worked as a research staff scientist at the Oak Ridge National Laboratory from [redacted] where he developed and used environmental transport and risk assessment methodologies.

In 1983, Dr. Meyer joined Chem-Nuclear Systems and helped open offices in Albuquerque, New Mexico, and Harrisburg, Pennsylvania. He directed the radiation protection, environmental monitoring, and cleanup verification efforts of the Uranium Mill Tailings Remedial Action Project and initial technical and siting development for the Pennsylvania low-level radioactive waste facility. In 1993, Dr. Meyer and Dr. Kathleen Meyer formed Keystone Scientific, Inc. to focus on risk assessment, dose reconstruction, and related activities. He has worked, primarily with *Radiological Assessments Corporation,* reviewing unclassified and classified records at the facilities and calculating historical offsite releases, doses, and risks associated with plant operations since the early 1950s.

Dr. Meyer's scientific achievements include more than 60 publications in the areas of environmental transport and risk assessment, facility siting, and uranium mill tailings cleanup.

## KATHLEEN R. MEYER, PH.D.
## KEYSTONE SCIENTIFIC, INC.

- Ph.D., Radiological Health Sciences, Colorado State University, Fort Collins, Colorado [redacted]
- M.S., Health Physics, Colorado State University, Fort Collins, Colorado, [redacted]
- M.S., Marquette University, Milwaukee, Wisconsin, [redacted]
- B.S., Carroll College, Helena, Montana, [redacted]

After graduation from Carroll College in Helena, Montana, in [redacted], Dr. Kathleen R. Meyer completed graduate studies in biology at Marquette University. In 1972, she was one of the organizing members of the Biology Division at the College of Lake County in Illinois, where she developed and taught courses in biology, genetics, and microbiology. Dr. Meyer received her master of science degree in health physics in [redacted] from Colorado State University. In [redacted] she received her doctorate degree in radiological health sciences from Colorado State University. She was a research assistant at Oak Ridge National Laboratory and assessed the radiation damage and subsequent recovery capabilities of normal tissue, both in cell culture and in animal models.

In 1982, Dr. Meyer began independent work in radiological dose assessments, technical abstracting, and chemical and radiological risk evaluation for sites containing hazardous materials. Through her company, Keystone Scientific, Inc., Dr. Meyer's present work focuses on evaluating past releases of materials from the Feed Materials Production Center the Savannah River Site, the Rocky Flats Plant, and the Idaho National Engineering and Environmental Laboratory. She is a member of the National Council on Radiation Protection and Measurements Scientific Committee 64-19 on Historical Dose Evaluation.

**H. JUSTIN MOHLER**

- M.S., Environmental Health Physics, Colorado State University, Fort Collins, Colorado, [redacted]
- B.S., Biology, Southwest Missouri State, [redacted]

Mr. Mohler received his bachelor's degree in biology from Southwest Missouri State in [redacted] From 1993 to 1994, he worked at Colorado State University collecting and preparing soil samples from the Rocky Flats Environmental Technology Laboratory. Mr. Mohler received a master of science degree in environmental health physics in [redacted] from Colorado State University. As a U.S. Department of Energy Health Physics intern, he analyzed the effects of building downwash for facility regulatory compliance using air dispersion codes and computer software.

In 1996, Mr. Mohler was employed as a research associate at Colorado State University where he conducted analyzed Rocky Flats soil samples, operated and calibrated detectors, and performed analysis and interpretation using computer software

Since January 1997, Mr. Mohler has worked as an independent scientific consultant. He was analyzed spatial and temporal trends in plutonium distribution and investigated the potential impacts of burrowing animals on plutonium dispersal at the Rocky Flats Environmental Technology Site in Colorado and the Hanford Site in Washington.

Mr. Mohler began working with *RAC* in April 1997. His work has focused on historical releases of radioactive and nonradioactive materials

**SUSAN L. SHARP**

- B.S., Civil Engineering, University of Arizona, Tuscon, Arizona, [redacted]

Ms. Sharp received her bachelor's degree in civil engineering from the University of Arizona in [redacted] she was a project engineer for Chevron, USA, Inc., where she conducted environmental site investigations and service station design and permitting. She also developed construction schedules and critical pathway analyses for retail service stations.

In 1990, she joined ORS Environmental Equipment as their southwest regional sales manager. In this position, Ms. Sharp provided designed environmental equipment systems used to remediate soil and groundwater.

Ms. Sharp began her career with BP Oil, Environmental Resources Management, in 1991. From 1991 to 1996, She managed over 150 site assessment and remediation projects. She also provided senior technical review of soil and groundwater assessment and remediation design.

In 1996, Ms. Sharp began serving as a team leader of environmental project engineers that are designing and implementing corrective action at petroleum and chemical facilities. Ms. Sharp has conducted site investigations, risk analyses, remediation designs, and corrective actions at over 250 sites in 18 states, including refining centers, terminals, pipelines, and retail locations. She has reviewed state and local regulations and legislation for their impact to corrective actions. Ms. Sharp also has experience working with the public, state, and federal groups and the media to communicate risk and increase stakeholder involvement.

**WARREN K. SINCLAIR, PH.D.**
**WARREN K. SINCLAIR, INC.**

- Ph.D., Physics, University of London, [redacted]
- Honors Course in Mathematics, University of New Zealand [redacted]
- M.S., First Class Honors in Physics, University of New Zealand, [redacted]
- B.S., Physics and Mathematics, University of New Zealand, [redacted]

Dr. Sinclair is a biophysicist with extensive publications in radiological physics, radiobiology, and radiation protection. He was born in New Zealand and educated in New Zealand and England before coming to the United States in [redacted] He served as physicist at the Royal Marsden Hospital, London from 1947–1954. Dr. Sinclair was chairman of the Department of Physics at the M.D. Anderson Hospital and professor of physics and zoology at the University of Texas 1954–1960. From 1960–1983, he was a senior biophysicist, division director, and associate laboratory director at Argonne National Laboratory in Chicago, Illinois. He is also an emeritus professor of radiology at the University of Chicago.

Dr. Sinclair was president of the National Council on Radiation Protection and Measurements from 1977–1991 and is now president emeritus. He is a member of the International Commission on Radiological Protection and a former member of the International Commission on Radiation Units and Measurements. He serves on the United States delegation to the United Nations Scientific Committee on the Effects of Atomic Radiation and is presently chairman of the board on radiation effects research at the National Academy of Sciences. He also serves on the board of the Radiation Effects Research Foundation in Hiroshima, Japan.

**PAUL G. VOILLEQUÉ**
**MJP RISK ASSESSMENT, INC.**

- M.S., University of Michigan, Ann Arbor, Michigan, [redacted]
- Masters of Basic Science, University of Colorado, Boulder, Colorado [redacted]
- B.S., University of Colorado, Boulder, Colorado [redacted]

Mr. Voillequé began his career as a health physicist for the Atomic Energy Commission in Idaho in 1967. He first participated in research on the environmental transport of radionuclides and performed internal dose calculations and personal exposure evaluations. Later, as head of the Environmental Studies Section, he planned and conducted experiments to measure the deposition of airborne $^{131}I$ onto vegetation and its transfer from vegetation to cows' milk and led research into real-time environmental monitoring of nuclear reactors.

In 1975, Mr. Voillequé joined Science Applications, Inc. and began to study the behavior of radionuclides within nuclear facilities and the mechanisms that led to their release. Beginning in April 1979, Mr. Voillequé contributed to Three Mile Island recovery studies, including identifying and measuring radionuclides in the plant, calibrating effluent monitors, and evaluating effluent filtration systems. He participated in evaluations of the radioiodine source term during the accident and was the principal investigator for a study to estimate radiation and particulate source terms during Three Mile Island Unit 2 defueling operations. Since founding MJP Risk Assessment, Inc. in September 1990, Mr. Voillequé has been part of a team conducting historic dose reconstruction projects at Fernald, the Savannah River Site, and Rocky Flats. He has estimated historical routine and accidental radionuclide releases from the facilities and evaluated the risks of exposures to airborne plutonium. He has been a member and is currently Chair of the panel that oversees a dose reconstruction project conducted by the State of Tennessee for historic Department of Energy facilities at Oak Ridge and made contributions to the National Cancer Institute study of doses from $^{131}I$ in fallout from the nuclear testing in Nevada.

Mr. Voillequé assists in conducting studies of the health impacts of the Chernobyl accident on populations in the Russian Federation, Ukraine, and Belarus. He achieved Comprehensive Certification in Health Physics in 1978.

## JILL M. WEBER

- M.S., Health Physics, Colorado State University, [redacted]
- B.S., Physics, Augustana College, [redacted]

Jill M. Weber received her undergraduate degree in [redacted] in physics with minors in chemistry and mathematics from Augustana College in Sioux Falls, South Dakota. Ms. Weber received her master of science degree in radiological health sciences with a specialty in health physics from Colorado State University in [redacted].

Ms. Weber began working with *Radiological Assessments Corporation* in October 1995. She has researched and developed models releases of plutonium from the 903 Area at the Rocky Flats Plant. Ms. Weber studied erosion, suspension, and meteorological data to characterized releases from a contaminated soil area at Rocky Flats that was exposed to high winds and resulted in significant releases. She also has conducted statistical calculations and uncertainty assessments for dose reconstruction projects.

Ms. Weber recently organized and managed the *RAC* audit of the Los Alamos National Laboratory for compliance with the Clean Air Act and was responsible for the environmental monitoring program portion of the audit.

### Other Support Staff

Leeann S. Denham, M.S. Project management and budget support
Sally J. Francis, B.S. Technical editing and report preparation
Phoebe J. Boelter, B.S. Report preparation and coordination

# C. PROPOSAL OF WORK

The Scope of Work (SOW) for this RFP requires seven tasks be performed that go beyond a simple review of the proposed soil action levels document. Each task is presented below as it appears in the RFP. With each task, we restate the actions required in the RFP, provide a summary of our proposed actions for performing the task, and then provide a justification and discussion of our approach. Project deliverables are identified at the end this section. Personnel assigned to each task and their level of effort are described in Section D.

## Task 1. Cleanup Levels at Other Sites

*Actions:*

- *Identify and evaluate cleanup levels and/or action levels (i.e., RSALS) which exist or are projected for use at other radionuclide contaminated sites (particularly with plutonium and americium) and the processes/models used to determine them as to their applicability in setting cleanup levels at RFETS.*
- *Identify any processes/models that were or are being used to determine offsite impacts to communities from onsite cleanup levels.*
- *Provide a summary of this evaluation itemizing the reasons why such levels or processes/models are or are not applicable for use in assessing cleanup levels for RFETS.*

*Considerations:*

- *This study should concentrate on examples of soil similarly contaminated with transuranic elements and, in particular, plutonium and americium. Of particular interest is the reasoning that went into the setting of these cleanup levels and the subsequent history of the site, including any cleanup. The study should compare the cleanup and/or action levels within the context of site-specific conditions, projected land use, and the then-existing risk assessments and dose standards. This portion of the study will be used to place the calculated RFETS values in context.*

***RAC* Proposed Actions for Task 1**

1. Evaluate all available soil cleanup and/or action level studies performed for either specific or generic sites.
2. Compare these cleanup levels at other sites with those proposed for RFETS.
3. Discuss the methods, assumptions, and relative merits of each study and its applicability to RFETS environment.
4. Identify the models and methods used in these studies that may be applicable to the RFETS environment.
5. Document findings in a report.

### Discussion and Justification of Approach

This task is important in putting the RFETS action levels into perspective and helping interested individuals understand how soil action levels are determined. Preliminary comparisons made by a concerned citizen (Joe Goldfield) have alerted us to the possibly high action levels for plutonium proposed for RFETS compared with plutonium action levels defined for other sites. The soil action level is defined as the soil concentration that results in a dose that does not exceed regulatory standards for annual radiation dose. In the case of Rocky Flats, a dose of 15 mrem $y^{-1}$ for a restricted release scenario and 75 mrem $y^{-1}$ for an unrestricted release scenario was stipulated.

The evaluation and summary of cleanup and/or action levels at other sites will (a) provide a description and history of the site for which action levels were defined, (b) indicate which radionuclides are present, (c) summarize pathways and exposure scenarios considered, (d) describe models and methodologies used to determine action levels, annual dose limits, and/or standards adhered to, and (e) list the final action levels established at the sites. Information gathered in this task may be summarized in tabular form. Emphasis will be placed on those sites having transuranic contamination, particularly plutonium and americium. Attention will be drawn to action levels that considered offsite impacts to surrounding communities. Models and methodologies used to calculate offsite impacts will be identified and reviewed for possible application to the RFETS environment.

In order to highlight the differences that methodology, site-specific conditions, and input parameter values have on action levels, we propose normalizing action levels to their annual dose limits. The normalized soil action level is the annual dose limit divided by the soil concentration (annual dose per unit activity concentration in soil). Normalized action levels focus attention on the methodology and input parameter differences by factoring out differences due to different dose standards. Results will be presented by exposure scenario in table format. These tables will assist in making valid comparisons between different action levels. Pathways will be listed in order of relative importance.

**Task 1: Cleanup Levels at Other Sites — Deliverables and Schedule**
After project initiation:
- *Monthly*: Meet with Oversight Panel and present latest findings, address concerns, and discuss future direction
- *3 Months*: Submit draft report to Oversight Panel and send out for peer review.
- *6 Months*: Incorporate the peer review comments and present final report to Oversight Panel.

## 2. Computer Models

*Actions:*
- *Identify and evaluate all relevant available or emergent models which can be used to calculate radionuclide contamination levels in soils based on a given dose rate.*
- *Evaluate the models to determine which are most applicable and best suited to model the site-specific conditions at RFETS.*
- *Provide a description of these models, a summary of the strengths and weaknesses of each, and a recommendation for the most appropriate model(s).*

*Considerations:*
- *Models that are inappropriate to RFETS site conditions, obsolete, or which cannot be readily validated should not be included. The RESRAD model must be included due to its use in determining the current RSALs. A comparison of the different models using RFETS site-specific data would be useful. The contractor is encouraged to find computer codes capable of modeling both onsite and offsite dose rates. If no models exist for this determination, the contractor will review offsite migration/impacts over time/distance for various cleanup levels. It is possible that no one model will prove satisfactory for determining both, but that a*

*combination of models may be necessary. The contractor will be expected to recommend the most appropriate model(s) for RFETS site-specific conditions and to justify this recommendation. Whichever model or models are recommended should be thoroughly validated. It is not necessary that the contractor perform this validation; peer reviewed, published studies will suffice. In the event that RESRAD is not recommended, RESRAD should be run in parallel with the recommended model(s) as a comparison.*

***RAC* Proposed Actions for Task 2**

1. *RAC* will search for existing or developmental computer programs that estimate radiation dose rate to an individual as a function of that individual's exposure to soils contaminated with radionuclides.
2. The programs will be evaluated for suitability for site-specific use at RFETS, and RESRAD will be included in the evaluation.
3. A summary report will describe the programs and recommend a program or prescribed use of a combination of programs for analyzing and establishing soil action levels for RFETS.
4. The search will include some general environmental assessment programs, which would have the capability of considering offsite migrations of radioactivity.
5. Recommendations will include the problem of extending validation of models and programs for RFETS applicability.

## Discussion and Justification of Approach

*RAC* will search for existing or developmental computer programs that estimate radiation dose rate to an individual as a function of that individual's exposure to soils contaminated with radionuclides. Such programs should be able to relate levels of radionuclides in soils on and near the RFETS to the dose rate over time to an individual who spends time both on and off the site and should be adaptable to scenarios of future exposure to a decommissioned site. The programs will be evaluated for site-specific applicability at RFETS. The criteria for rating computer programs will include

(1) The validity of mathematical models implemented by a program: acceptance among scientists, logical correspondence with the features of the site, treatment of exposure pathways, and consistency with the available site data

(2) Amount and quality of validation of a program that has been carried out and documented, and the program's suitability for local validation

(3) Program documentation (including user manuals) and availability of source code

(4) The platform (i.e., computer and operating system under which the program runs) and programming language, assuming the source code is available

(5) Flexibility of operational features, including the option of controlling the program from the operating system's command line, with input data in an electronic file, rather than being required to communicate with the program exclusively through a graphic user interface (pointing and clicking with a mouse).

It is useful to distinguish between the terms "model" and "computer program." A model is a conceptual construct that draws on scientific knowledge to describe part of a real system in a quantitative way. A computer program implements one or (usually) more models, using the equations that describe them to perform calculations that simulates movement of contaminants through environmental media (such as air, soils, water, and food) and estimates doses to people exposed to those media. A program usually has elaborate input/output and reporting capabilities.

Validation seeks to test computer programs by comparing their predictions with measurements made under field conditions similar to those simulated by the programs. All such validation exercises are restricted to specific places and conditions, and even extensive validation of a program does not ensure correct results if the program is applied uncritically to a particular location and problem. *RAC* has usually found it necessary to perform validation calculations based on site-specific data.

The possibility of local validation of any selected programs is of fundamental importance, and it is not a routine procedure. It requires careful study of available site data and formulation of tests using the candidate program with appropriate assumptions and input data to permit comparison of outputs with site-specific measurements. The results often indicate an unacceptable correspondence, and if so, it is necessary to reexamine the assumptions. Sometimes calibration of the model to site data is required. This means that by an analysis of the relationship between the local input data and the corresponding predictions, a factor or formula is arrived at by which the predictions of the program will be adjusted for local use. Although the adjustment is necessarily based on limited data, it is expected that a general degree of improvement of local predictions will result. For example, in both the Fernald and the Rocky Flats dose reconstruction studies, *RAC* found that generic atmospheric transport models did not acceptably reproduce air concentrations measured at those sites without some calibration to measurements made over limited periods of time.

Analysis of propagated uncertainties is essential to the establishment of credible soil action levels, and such analysis requires substantial use of Monte Carlo computer simulation methods. In some circumstances, the inclusion of Monte Carlo instructions in the reviewed program could be useful, but the kind of flexibility described in item 5 (above) is preferred so that the Monte Carlo analyses could be scripted and carried out at the operating system's command level, with the program being executed repeatedly with input files generated from sampled input values. In this way, the analysis is not restricted by the particular uncertainty design that the developers built into the program's logic; this hardwired design may not be best for the applications at hand.

Source code usually is not available if a program is a commercial product. Although we would not automatically reject a program for which the source code is proprietary, one must consider that an examination of source code can often resolve the inevitable questions about the models and how they are implemented that are not answered in the documentation. And it frequently happens that one needs certain outputs that the program's developers did not anticipate but that can be provided by inserting a print statement into the source code and recompiling; this remedy is not possible without the source code. *RAC* is *not* proposing to perform an extensive review of the source code of any candidate program; rather, *RAC* considers the availability of the source code an assurance that whatever checking and probing that it deems appropriate can be done.

The platform is of concern only if it imposes obstacles to examining and working with a candidate program. Programs for which source code in one of the languages FORTRAN, C, or C++ is available should present no serious problem. Programs that have been developed to operate under Windows 95 or Windows NT should also be manageable. Programs without source code that are distributed as binaries native to non-Intel workstations would require special arrangements.

The RESRAD program will be included in this evaluation, as required by the RFCAB. *RAC* will ask the RFCAB to make every effort to help persuade DOE to make available the RESRAD source code for purposes of the evaluation and subsequent application of the program. To the best of our knowledge, this source code has never been made public.

Software quality assurance issues are addressed in the *RAC* Software Quality Assurance Plan. In brief, the *RAC* plan requires that off-the-shelf software include ample documentation to verify that the code operates correctly and performs the calculations that it claims. Software developed by *RAC* will include documentation that will state (a) the purpose of the software, (b) the mathematical equations imbedded in the code, (c) solution techniques, and (d) sample applications.

**Task 2. Computer Models — Deliverables and Schedule**

After project initiation:

- *Monthly*. Meet with Oversight Panel and present latest findings, address concerns, and discuss future direction.
- *4 Months*. Submit draft report to Oversight Panel and send out for peer review.
- *7 Months*. Incorporate the peer review comments and submit final report to Oversight Panel.

## 3. Inputs and Assumptions

*Actions:*

*Evaluate the input parameters, inputs, default inputs, and assumptions for the current analysis (RESRAD) used to set the RSALs at RFETS. At a minimum, this evaluation must satisfy the following:*

*(a) Are the input parameters, inputs, default inputs, and assumptions adequate, accurate, and credible in simulating the conditions at RFETS, given the future land use scenarios envisioned in RFCA, and the subsequent conversion to dose rate/contamination levels?*

*(b) For each of the input parameters, what is the sensitivity of the input values in terms of resulting contamination levels?*

*(c) For each of the input parameters, what is the distribution of possible input values? Identify each of these based on the sensitivities determined in (b) above from least conservative to most conservative, with conservative meaning that which results in lower contamination levels given a certain dose limit. Quantify the uncertainties of the inputs or input distributions.*

*(d) For each of the input distributions in (c) above, identify an input value which can be considered "reasonable" or "best estimate." Provide the reasoning for these choices.*

*Considerations:*

*All of the input parameters to the model need to be examined. Parameters that are easily confirmed, non site-specific parameters, or those which are specified by the EPA or other regulatory agencies, should be noted as such. If the investigation indicates that such values are not appropriate, alternatives should be recommended. Parameters for which there are site-specific input data for RFETS should be identified and a thorough study of the distribution of possible values should be performed.*

***RAC* Proposed Actions for Task 3**

1. Evaluate input parameters, default inputs, and assumptions for adequacy, accuracy, and creditability concerning current and future land use scenarios and conversion to dose rate/contamination levels. This includes evaluating exposure scenarios defined for soil action levels in terms of their creditability for addressing doses for future land use scenarios.
2. Perform a sensitivity analysis of one parameter at a time with RESRAD using the cases developed for the proposed soil action levels. Determine which parameters are *unlikely* to contribute substantially to the overall uncertainty in the soil action levels. Consideration will be given to the sensitivity of the individual parameter and how that parameter is used in the underlying RESRAD equations.
3. Develop uncertainty distributions for parameters that are not selected in (1) from site-specific data if available. Literature will be reviewed if site-specific data does not exist.
4. Write a computer interface for RESRAD that performs Monte Carlo calculations on the parameters not selected in (1) and stores output.
5. Perform Monte Carlo simulations using the distributions developed in (2) for the exposure scenarios defined for the proposed soil action levels and any alternate scenarios the Panel wishes to include.
6. Extract from the Monte Carlo output, the sensitivity of the soil action levels to each input parameter, and the uncertainty in the overall action levels. Report results by exposure scenario.
7. Document and interpret results in a report.

## Discussion and Justification of Approach

This phase of the SOW essentially requests that a quantitative sensitivity/uncertainty analysis be performed on the RESRAD simulations used to generate the proposed soil action levels. In addition, input parameters and exposure scenario assumptions are to be reviewed and evaluated in terms of their credibility for assessing doses considering the future land use scenarios.

For the evaluation of the suitability of input parameters for establishing RSALs at RFETS, *RAC* can draw on its experience in evaluating and applying environmental monitoring data collected at the RFETS and vicinity. This includes data that characterizes environmental conditions such as meteorology, soil characteristics, and hydrology. Exposure scenarios will also be reviewed and alternative scenarios suggested.

In this task, *RAC* also proposes to do a Monte Carlo sensitivity/uncertainty analysis on the proposed soil action levels. The current version of the RESRAD model contains features for performing sensitivity analysis. However, the methods used by the code are only designed to evaluate sensitivity for one parameter at a time and do not consider interaction and correlation between parameters. A sensitivity analysis that considers interaction and correlation between parameters requires random sampling from distributions and is typically more involved than an approach that treats one parameter at a time. The latter kind of approach may be useful at the onset of a sensitivity analysis, but a thorough understanding of the sensitivity of the output variable to changes in the input requires a random sampling approach. For example, the output variable's sensitivity to parameter $X$ may change as another parameter $Y$ is varied. A meaningful sensitivity analysis requires that distributions of input parameters (at least in preliminary form) be developed first. Then, using Monte Carlo sampling techniques, the sensitivity of the output variable to each input parameter can be determined. This approach has the added benefit of providing a quantitative uncertainty analysis of the RESRAD derived soil action levels. The uncertainty analysis results can be used to make valid comparisons to soil action levels determined using other models and codes as stipulated in Task 5.

A beta test version of the RESRAD program that includes routines to perform Monte Carlo sampling and uncertainty analysis is available. However, the program has not been thoroughly tested, verified, and validated at this time. It is unknown when the final version of this program will be released. As an alternative to using the beta test version of RESRAD, we propose writing our own Monte Carlo sampling routines using verified and validated sampling routines available in the public domain. The interface with RESRAD will require knowledge about how RESRAD reads and writes model data. *RAC* has researched this option with the RERAD software developers.[b] Our research has indicated that our approach is both feasible and attainable in the allotted time. Communication between the computational portion of RESRAD and its graphical-user interface (GUI) is routed through several ASCII files. Our custom interface will (a) randomly sample from the distributions derived in Subtask 2, (b) write the necessary RESRAD input files, (c) run the RESRAD code, and (d) extract and store the results from the RESRAD output. Ideally, we would like to obtain a copy of the source code and an effort will be made to do this. However, the success of this approach is not contingent upon receipt of the source code. The interface will be written in a standard programming language (C++ or FORTRAN). We will not modify any of the computational parts of the RESRAD program, and we will check code output using our interface with output generated using the GUI to assure our interface is operating properly. The interface source code will be available to the Oversight Panel for independent review.

Parameter distributions will be defined in terms of standard distributions (i.e. normal, lognormal, uniform, triangular) or, if required, a custom distribution will be constructed. Typically, statistics like the mean and standard deviation are used to describe the distribution, but for nonsymmetric distributions, three or more standard percentiles (such as the 5th, 50th, and 95th) are sometimes better indicators. Attention will focus on those parameters that determine concentrations of radionuclides in environmental media (soil, air, and water). Parameters that define the exposure scenario and physical attributes of the receptor will be addressed separately by defining alternative exposure scenarios and computing action levels for each of these scenarios. Parameter distributions will be developed from site-specific data if available. If site-specific data are lacking, the available literature will be reviewed for appropriate values.

Monte Carlo calculations will then be performed on all scenarios including the original scenario used to establish the proposed soil action levels. Results may be summarized in tabular form showing the percentile values of the output distribution. However, other statistics describing the distribution may be reported as well.

This approach has a number of advantages in that both uncertainty and sensitivity are quantified for soil action levels. Proper interpretation of results is critical to understanding the meaning of the output in the context of the assessment question. As part of our documentation, we will include a detailed section (with examples) on how a layperson may interpret results of the sensitivity and uncertainty analysis, pointing out the implications in terms of soil action levels.

[b] Oral communication with David LaPore, Argonne National Laboratory, July 1, 1998.

*RAC* personnel have over 50 years combined experience in scientific software development and computing and are qualified for this task, having written many custom software applications employing Monte Carlo sampling for the Fernald and Rocky Flats Dose Reconstruction Projects.

**Task 3. Inputs and Assumptions — Deliverables and Schedule**
After project initiation:
- *Monthly.* Meet with Oversight Panel and present latest findings, address concerns, and discuss future direction.
- *8 Months.* Submit report to Oversight Panel and send out for peer review.
- *11 Months.* Incorporate the peer review comments and submit final report to Oversight Panel.

## 4. Methodology

*Actions:*
- *Identify and evaluate the methodologies which can be used to select or combine the necessary inputs/outputs for a given computer model in determining contamination levels for a given dose limit.*
- *Within one (1) month of the start of the contract, present to the Oversight Panel and stakeholders a summary of these methodologies along with a recommendation and justification as to the best suited for such an analysis.*
- *Compare or contrast this recommended methodology with that used in the existing RESRAD analysis.*

*Considerations:*
- *It is understood that there are several methodologies (e.g., bounding, best estimate, conservative, probabilistic risk assessment, etc.) which can be used to shape the inputs for such an analysis. The question as to "how conservative is conservative?" makes this a subjective rather than simply a scientific issue, because the affected communities must accept the risks involved. Therefore, the Oversight Panel wishes to fully understand the nature and implications of each of the potential methodologies to ensure that the methodology chosen can best produce credible and defensible results from this independent review which will be acceptable to the broadest range of stakeholders.*

***RAC* Proposed Actions**
1. *RAC* will review the approaches to interpretation of data and results in simulation ("methodologies") and develop a discussion of these approaches.
2. No later than one month after the beginning of the contract, *RAC* will present the discussion of item 1 to the Oversight Panel and stakeholders.
3. *RAC* will recommend to the Oversight Panel an approach, based on state-of-the-art methods of uncertainty analysis, to relate concentrations in soil to annual radiation doses to individuals represented in specific exposure scenarios.

## Discussion and Justification of Approach

In our experience, terms like "best estimate," "conservative," and "probabilistic risk assessment" sometimes have different meanings for different people. Instead of discussing the representation of inputs (parameters) and predicted values in terms that might be misconstrued, we believe it would be useful to summarize *RAC's* recommended approach to the treatment of quantitative information that is subject to uncertainty. This includes initial values, parameters, and calculated quantities.

If we consider the scenario definitions and dose limits fixed, then all uncertainty is associated with the calculated soil action levels. One view of our goal is to estimate a probability *P* that the annual dose limit will not be exceeded if the soil contamination equals any specified level (including the soil action level), given the exposure scenario. The probability *P* should be interpreted as a measure of confidence based primarily on the uncertainties in parameters and data; it does *not* represent the fraction of an exposed population for which the annual dose does not exceed the limiting value. Thus, *P* does not represent the probability that an individual would be exposed; all individuals described by the scenarios are exposed by definition. What we would estimate is a level of confidence that the exposure would produce an annual dose that does not exceed a set limit, given contamination at the soil action level. From another point of view, our goal would be to start with the exposure scenario and its fixed annual dose limit and to calculate the corresponding soil action level as an uncertain quantity. This latter interpretation entails some additional complications, but the underlying mechanisms of computation are the same.

We would not ordinarily interpret the exposure scenarios themselves as uncertain, although some gray areas exist. It generally is less confusing to take the scenario definitions as given and confine the uncertainty to environmental measurements and transport simulations (uncertainties in environmental transport often dominate any uncertainties hypothesized for the scenarios). When questions arise concerning scenario features, it usually is preferable to address them by considering alternative scenarios that change only the features in question.

In performing uncertainty analysis, *RAC* emphasizes the following principles:

A. Uncertainties are represented by distributions of probability. The distributions may apply to single (scalar) numeric variables (the most commonly discussed case) or jointly to multiple variables that may be either stochastically independent or dependent, depending on the interpretation. The distributions can be communicated and explained by various quantitative and graphic devices, such as giving certain percentiles (5th, 50th, 95th) and by showing plotted scatter charts and histograms. Such devices need to be chosen and presented with the background of the audience in mind.

B. *RAC* generally recommends that calculations *not* be deliberately biased high to compensate for lack of knowledge. Rather, analysts should do their best to keep their procedures free of bias. Conservatism, when warranted, should be expressed by increasing the variance of a quantity's uncertainty distribution while keeping its "center" (e.g., 50th percentile) fixed. (The variance is a measure of a distribution's spread or dispersion. The variance is inversely related to the precision with which the quantity is known: if the variance is large, the quantity is known with low precision.) An exception to this general principle occurs in dealing with quantities that are unlikely to affect the outcome of a calculation to a significant degree, in which case the quantities in question may be judiciously biased high.

C. Uncertainties for input variables may be estimated from sample distributions of data, from analytic considerations (e.g., physical arguments that establish bounds for the quantity), by analogy with similar or related quantities, or by seeking consensus of experts. Sometimes nonrigorous arguments based on weight of evidence are persuasive, but when they are offered, they must be acknowledged as such. In doubtful cases, the sensitivity of the outcome to the questioned parameter should be examined; if there is little effect, excessive concern may be unjustified. If there is significant effect, the variance of the uncertainty distribution of the parameter should be increased to a point where there can be little doubt that the distribution includes all values. If such a point cannot be agreed upon, or if the affect on the outcome is so great as to render it virtually meaningless, then further research must be undertaken or alternative simulation strategies must be sought.

D. Results usually should not be presented as point estimates (i.e., single "hard" numbers, such as 2.7 pCi $g^{-1}$). The desired estimate of the quantity is a distribution, and unambiguous and sufficient information about it should be disclosed (e.g., 5th, 50th, and 95th percentiles; less desirable for nonsymmetric distributions are mean and standard deviation).

E. Explanations should be framed to avoid misunderstandings about the interpretation of statements involving probability.

*RAC* has substantial experience in applying these principles to real environmental assessments that present difficulties and complications never encountered in textbook discussions. With the statement of these principles, *RAC* discloses its position with regard to the approach to preparation of input quantities and interpretation of results in the proposed estimation of soil action levels. We agree with the Oversight Panel that the imposition of limits on conservatism introduces subjectivity into the process, and we are prepared to assist the Oversight Panel in contrasting this approach with other options. In particular, the approach we advocate focuses the issue of conservatism on the probability $P$ that the annual dose limit of the scenario will not be exceeded if the soil radionuclide level equals the soil action level. Accordingly, we will develop a presentation for the Oversight Panel and stakeholders, to be given at the end of the first month of the contract, in which these options and their implications are examined as thoroughly and as clearly as this very brief preparation time permits.

**Task 4. Methodology — Deliverables and Schedule**
After project initiation:
- *1 Month.* Meet with Oversight Panel and present methodology approaches for interpretation of data and results.
- *Ongoing.* Incorporate discussion items into the methodology used in the independent calculation of soil action levels. Incorporate findings in appendix of final report.

## 5. Independent Calculation

*Actions:*
- *Using the methodology recommended in 4. above, select/combine the inputs identified in 3. above, as well as any new inputs required by the model recommended in 2. above in that model to calculate contamination levels for the dose limits set for each of the RFCA land use scenarios assumed in the original analysis. This includes a residential scenario.*
- *As part of the calculations, include a statement of the assumptions and level of uncertainty involved in the specific approach utilized. State the dose limits in terms of risk.*

*RAC* **Proposed Actions for Task 5**

1. The computer programs identified in Task 2 will be used to calculate soil action levels, using the methodology identified in Task 4.
2. Programs will be set up to carry out Monte Carlo uncertainty analysis with the calculations. We will estimate probability distributions for soil action levels, interpret the distributions, and provide a statement of confidence in the results.
3. Soil action levels will be derived for each of the land use scenarios assumed in the original analysis and for the alternative scenarios identified in Task 3 if this is requested by the Oversight Panel.
4. Carcinogenic incidence risk will be estimated for each annual dose limit.

## Discussion and Justification of Approach

This task will be built on what has been learned in carrying out Tasks 2–4 and will provide what we expect to be defensible soil action levels. The soil action levels will be presented in terms of uncertainty distributions, and we will provide a report that discusses these distributions in their proper context.

Each scenario presents a prescribed annual dose limit that constrains the levels of radionuclides in the soil within and contiguous with the RFETS. The calculation gives the radionuclide level in the soil as a function of the annual dose, and the uncertainty analysis provides a probability distribution for the radionuclide level in the soil. This probability distribution is based on the uncertainties specified for the model input parameters. This distribution represents the soil action level when the annual dose has its limiting value. *RAC* will compute soil action levels for each of the exposure scenarios (including the alternative scenarios from Task 2 if requested to do so) and provide the uncertainty analysis and interpretation that is an integral part of the process.

Some complications occur because of multiple radionuclides. If the sum of ratios method is followed, the distribution of soil action level is determined for each radionuclide separately. When measurements of the radionuclides in soil are made, the method consists of summing the ratios of the measured values divided by the corresponding soil action levels. If the sum exceeds 1, the combined action level is exceeded. When uncertainty distributions are involved, however, the distribution of the sum of ratios must be estimated from the distributions of the individual ratios and from estimates of sampling error. The probability $Q$ that the sum of ratios exceeds 1 is calculated from the distribution of the sum, and the criterion for action is based on the magnitude of $Q$. Because of correlations within the calculation, it is preferable when possible to perform the calculations with all radionuclides present at once to avoid distortion of the distribution of the action criterion. We will clarify these correlation effects in the report and develop ways, with input from the Oversight Panel, of dealing with them.

*RAC* will perform these calculations based on the recommended programs, models, and methods and compare the results with the RESRAD approach. It should be emphasized that the credibility of the results has more to do with analysis, assumptions, data, definitions of scenarios, handling of uncertainty, and clear explanations of the methods used than on the formalistic execution of any specific computer programs.

The connection between annual dose to exposed individuals in a scenario and risk of cancer incidence is itself subject to uncertainty. *RAC* will provide estimates of this risk for each of the prescribed annual dose limits based on contemporary estimates of the uncertainties for the radionuclides and exposure modes that are relevant to this work.

**Task 5. Independent Calculation — Deliverables and Schedule**
After project initiation:
- *Monthly*. Meet with Oversight Panel and present latest findings, address concerns, and discuss future direction.
- *9 Months*. Submit draft report to Oversight Panel and send out for peer review.
- *12 Months*. Incorporate the peer review comments and submit final report to Oversight Panel.

## 6. Protocols

*Actions:*
- *As an integral part of the recommendations about the RSALS, recommend specific soil sampling procedures to be followed as an appropriate method of monitoring actinide concentrations in soil before and after remediation.*

*Considerations:*
- *It is necessary to find a scientifically credible method for guaranteeing that the cleanup levels will actually be met in terms of what contamination levels are ultimately measured at the site. This study should clearly delineate such parameters as sample spacing, depth of samples, sampling methods, and all associated quality assurance which ensures that the methods used for measuring contamination before and after any remediation are directly applicable to the parameters used for setting the cleanup levels. The technical literature on valid statistical approaches should be reviewed to verify sampling methods and recommend approaches that are appropriate for the cleanup at RFETS.*

***RAC* Proposed Actions for Task 6**
1. Review and evaluate established soil sampling methodologies for application to RFETS.
2. Recommend a soil sampling protocol that addresses characterization sampling to determine the nature and extent of contamination before remedial efforts and verification sampling to assess remaining residual contamination after remediation.
3. Provide a review of the current methods of sampling and analysis at RFETS.
4. A literature review of soil sampling design based on statistical considerations and incorporate the information into the recommended sampling design.
5. Address quality assurance issues regarding data quality objectives, documentation, chain-of-custody, laboratory requirements, and data validation.

### Discussion and Justification of Approach

A recommended specific soil sampling protocol will be developed to accompany the proposed RSALs. The protocol is necessary to provide a mechanism to evaluate the ability to attain RSALs in the environs of RFETS. The soil sampling protocol will allow decision making regarding site remediation by providing methods that statistically compare the RSALs with field data in a scientifically defensible manner that allows for consideration of uncertainty.

The sampling protocol will address two aspects of soil sampling: (1) characterization sampling to determine the nature and extent of contamination before remedial efforts and (2) verification sampling to assess the remaining residual contamination after remediation. Characterization sampling is necessary to ensure that adequate remedial measures are taken to ascertain attainment of the RSALs. Verification sampling is required for "proof" of acceptable remediation efforts and that the RSALs have indeed been attained.

The soil sampling protocol will provide RFETS with recommended methodologies for the determination of sample spacing, sampling depth, sampling methods, and quality assurance. The acceptance and implementation, through the development of policy and procedures, will be the responsibility of RFETS.

Current methods of sampling and analysis at the RFETS will be reviewed. This review will include pertinent procedures, sampling methods, packaging, chain-of-custody requirements, analytical methods, and quality assurance requirements. The review of current RFETS sampling methods will provide the basis for comparison to other industry standards and methods and the determination of the adequacy of existing RFETS methods.

The soil sampling protocol will include recommendations for sample spacing, depth of samples, sampling methods, and quality assurance. Each of these key areas of the soil sampling protocol will be addressed as described below.

The determination of sample spacing will be based upon statistical techniques. Currently, several methods have been proposed and others have been embraced by regulatory agencies for determining appropriate sampling strategies. Historically, this problem has been addressed at the Nevada Test Site. Recently, the "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM) was developed through cooperation of the U.S. Environmental Protection Agency, DOE, U.S. Nuclear Regulatory Commission, and U.S. Department of Defense. In addition, several investigators such as R.O. Gilbert, D.A. Singer, D.F. Parkhurst, have developed methods for statistical sampling based upon hot spot detection, geometrical grid patterns, and statistical significance testing. A review of the available techniques, potential applications at RFETS and an evaluation of implementation requirements will be conducted and recommendations provided in the final report.

The main factor for consideration in any of the available sample spacing, or conversely the number of samples, involves the specification of Type I (false positive) and II (false negative) errors. Variation in sampling and laboratory analyses will introduce uncertainty into the decision regarding the attainment of RSALs at RFETS. As a result of these uncertainties, the site may be judged to meet the RSALs, when in fact, it may not, resulting in a false positive decision, or Type I error. Conversely, the site may be judged to require additional remediation to attain the RSALs, when in fact, it may require no additional remediation, resulting in a false negative decision, or Type II error. The key to determining the appropriate spacing for soil samples lies in the ability to appropriately define acceptable Type I and II error levels in terms of both health protection and consideration of sampling costs. Acceptable Type I and II error levels will be evaluated considering health protection but balanced with sampling costs.

Soil sampling depths will be determined based upon the derivation of the RSALs, applicable parameters, and transport/exposure pathways. Depth of sampling is highly dependent upon the nature of the contamination in terms of mobility, depth distribution, and availability to potential receptors by various transport pathways. Recommendations will be provided in the sampling protocol for the depth of soil samples and other relevant issues including sample compositing, biased sampling, and sample stratification.

Sampling methods will be evaluated and proposed in the soil sampling protocol. Methods for collection of the soil samples in the field, including equipment, decontamination of sampling instruments, sample packaging, labeling, and documentation will be addressed.

Quality assurance issues will be addressed in the soil sampling protocol. Quality assurance issues will include recommended data quality objectives, documentation, chain-of-custody, laboratory requirements, and data validation. The assessment of data quality indicators (including precision, bias, representativeness, comparability, and completeness) will be completed and recommendations provided for determining sample and laboratory data usability.

**Task 6. Sampling Protocols — Deliverables and Schedule**
After project initiation:
- *Monthly*. Meet with Oversight Panel and present latest findings, address concerns, and discuss future direction.
- *5 Months*. Submit draft report to Oversight Panel and send out for peer review.
- *8 Months*. Incorporate the peer review comments and submit final report to Oversight Panel.

## 7. Actinide Migration

*Actions:*
- *Meet with the Actinide Migration Panel to share information in order to ascertain the applicability of any results from the actinide migration studies on the inputs to the modeling for this analysis.*
- *Study these results and any other relevant data and make a preliminary determination of what impact these will have on the results such as obtained in 5. above.*

*Considerations:*
- *Ultimately, cleanup levels must be protective of offsite residents. Calculations for the existing RSALs only considered onsite exposure scenarios. Since offsite air and water quality standards are more restrictive, it is possible these standards will control the cleanup. How can the issue of plutonium migration be incorporated into an evaluation of the RSALS? An Actinide Migration Study is currently underway. The final results of this study will not be ready in time to be used in this study. Some preliminary results will, however, be available. It is understood that any conclusions that can be based on this are tentative pending the completion of the Actinide Migration Study. The contractor should, however, identify the data needs of this study as early as possible in order to facilitate the collection and analysis of additional data needed.*

***RAC* Proposed Actions**
1. Meet with the Actinide Migration Panel early in the project to review their current understanding and evidence of actinide migration at RFETS.
2. Based on the findings in (1), consider what other pathways may be relevant for evaluation of offsite exposures.
3. Evaluate what potential impact actinide migration will have on the soil action levels, given offsite dose limits and water quality standards for offsite exposure may be more restrictive.
4. Identify data gaps that will impact future hydrologic studies of actinide migration from the RFETS.

## Discussion and Justification of Approach

The potential for offsite migration of actinides deserves attention at the outset of the study. Information gathered in this task should be integrated with the model selection task (Task 2) so that all relevant pathways of exposure to receptors both onsite and offsite are included. Special emphasis will be placed on aqueous phase transport because drinking water contamination has the potential to affect hundreds of thousands people in the surrounding communities. However, other pathways of migration will also be given due attention including resuspension and atmospheric transport. If necessary, simple bounding-level calculations will be used to estimate the relative importance of these migration mechanisms.

If it appears that surface and drinking water pathways have the potential to affect the soil action levels significantly then the capability to address them will be considered an essential part of any recommended suite of environmental models to be used to develop soil action levels. Potential pathways of concern include atmospheric, groundwater, and surface water. While we can select models that include the groundwater and surface water pathways, it is unlikely these models would have the level of detail required for an in-depth evaluation of these pathways. Models that are typically used to estimate groundwater and surface water contaminant movement require specialized expertise and data requirements. While some *RAC* personnel have expertise in using these models, the time and resources required to run them far exceed the time constraints of this study. Moreover, the final results of the actinide migration study need to be finalized before detailed hydrologic modeling can proceed. Therefore, any attempt to address this pathway will be semiquantitative in nature and the results should be interpreted as such. More importantly, the data needs of a future hydrologic investigation can be identified at this time.

**Task 7: Actinide Migration — Deliverables and Schedule**

After project initiation:

- *Monthly*: Meet with Oversight Panel and present latest findings, address concerns, and discuss future direction.
- *Quarterly or as needed*: Meet with Actinide Migration Panel; summarize meeting in letter report to Oversight Panel.
- *Ongoing*: Incorporate findings into final reports.

### Project Deliverables

A comprehensive report will be generated at the end of this project. The main body of the report will be directed to the level of the educated public and will summarize our findings and recommendations. Four appendices will provide the technical details of our work. The appendices will cover the following technical topics

| | |
|---|---|
| Appendix A | Cleanup Levels at Other Sites |
| Appendix B | Computer Models, Methodology, Input Assumptions, and Independent Calculation |
| Appendix C | Sampling Protocol |
| Appendix D | Summary of Meetings with the Actinide Migration Panel |

Each appendix will be written to be a stand-alone report, thereby, facilitating peer review of individual pieces of the overall project. Appendix B includes the material for four of the tasks

(Tasks 2–5). Each task will be provided in a separate section in the appendix to allow peer review as the draft documents are produced.

*RAC* will provide assistance to the Oversight Panel in preparing a separate summary report directed to members of the general public who are unfamiliar with the current proposed Residual Soil Action Levels (RSAL). It is *RAC's* understanding that the responsibility of producing the summary report for the public resides with the Oversight Panel. *RAC* has had considerable experience assisting other oversight panels in preparing newsletters and fact sheets for distribution to the public.

## D. WORK AND FISCAL MANAGEMENT

This section explains how the Review of Soil Action Levels Project will be organized, staffed, and managed by *RAC* and how the management and coordination of consultants will be accomplished. A profile of *RAC* is provided first, followed by detailed estimate of the number of hours anticipated to complete each task and personnel involved. Cost control and budget variance procedures are described last.

### Company Profile.

*RAC* was founded in 1977 by Dr. John Till. *RAC* is a of a team of independent consultants who have demonstrated their ability to work together to complete complex technical tasks in a timely and efficient manner. Dr. John Till, the president of *RAC*, provides team leadership and is the overall principle investigator of the team. Although *RAC* Team members are independent, these professionals share a commitment to teamwork and mutual support. *RAC* has taken advantage of advances in telecommunications equipment during recent years that makes communication between team members easy and efficient. All team members have state-of-the-art Pentium II computers equipped with high-speed modem and fax capabilities and telephone message systems. In addition, *RAC* Team members have electronic mail capabilities and access to a dedicated bulletin board system and file-transfer-protocol site.

Dr. Till assigns day-to-day management of a project's details to technical project leaders. Tracking of the project status is done by these leaders and also by Leeann Denham, who tracks milestones and project budgets for all *RAC* projects. While *RAC* Team members live and work in locations throughout the United States, Dr. Till regularly meets with individuals or small groups of *RAC* professionals whenever opportunities arise. Key team members will also meet in conjunction with the monthly Oversight Panel meetings. More formal *RAC* Team meetings are held several times a year, at least quarterly. At these intensive sessions, each current project is given a thorough review, schedules and anticipated deliverables are carefully examined, and technical details of specific segments of the work are examined by the group.

### Hour Estimates

Table 2 lists the proposed hours *RAC* anticipates to complete the project in the one-year time frame as stipulated in the RFP. Hours are itemized by persons performing the work and by task. We have separated the project into the seven tasks identified in the Proposal of Work and added an additional task (Task 8) for Oversight Panel interface and other responsibilities. Interface with the Oversight Panel is described in Section E.

### Procedures for Cost and Schedule Control

The RFP states that procedures should include methods to identify budget variances at the earliest possible time, as well as maintain the schedule. Efficient cost control measures are necessary to insure that the project is cost-effective. A fundamental element of *RAC's* cost management process is the integration of resource planning (completed before project initiation relying heavily on past experience and expert judgment); cost estimating (closely coordinated with resource planning); cost budgeting (resource planning and cost estimating result in a cost baseline budget that will is used to measure and monitor cost performance); and cost controlling (monitoring cost performance, ensuring all changes are accounted for in baseline budget and informing the RFCAB of the changes). In addition to closely monitoring spending and



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forecasting potential budget issues, *RAC* is also concerned about the impact of budget decisions on all project stakeholders, specifically, the RFCAB. The project baseline budget will be compared with the actual spending at least monthly to forecast any effects of cost changes. Tools used to track the interaction of these various aspects include both spreadsheets and project management software. Whenever possible, causes of budget variances are documented so that they become part of *RAC's* historical database for future cost management planning. It is the project manager's responsibility to ensure that the task is on schedule and within budget. The *RAC* tracking manager issues monthly budget reports to the project manager.

**Table 2. Hourly Breakdown of Staff Level of Effort by Task**

| Task | J. Till | H. Grogan | G. Killough | K. Meyer | R. Meyer | J. Mohler | A. Rood | S. Sharp | W. Sinclair | D. Thorne | P. Voilleque' | J. Weber | P. Boelter | L. Denham | S. Francis | Total Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task 1: Cleanup Levels at Other Sites | 40 | 8 | 32 | 16 | 16 | 16 | 44 | 16 | 0 | 32 | 16 | 24 | 20 | 20 | 20 | 320 |
| Task 2: Computer Models | 36 | 48 | 160 | 24 | 24 | 0 | 120 | 40 | 0 | 120 | 40 | 64 | 20 | 44 | 20 | 760 |
| Task 3: Inputs and Assumptions | 60 | 48 | 184 | 48 | 48 | 28 | 216 | 28 | 0 | 176 | 48 | 48 | 20 | 60 | 20 | 1032 |
| Task 4: Methodology | 16 | 0 | 24 | 8 | 8 | 0 | 32 | 8 | 8 | 24 | 8 | 16 | 8 | 8 | 0 | 168 |
| Task 5: Independent Calculation | 56 | 24 | 144 | 28 | 28 | 32 | 144 | 32 | 120 | 128 | 40 | 64 | 20 | 48 | 20 | 928 |
| Task 6: Protocols | 48 | 52 | 128 | 56 | 24 | 20 | 128 | 40 | 0 | 152 | 56 | 48 | 20 | 44 | 20 | 836 |
| Task 7: Actinide Migration | 72 | 0 | 24 | 56 | 56 | 0 | 40 | 16 | 0 | 8 | 48 | 0 | 12 | 20 | 12 | 364 |
| Task 8. Interfacing and Responsibilities[a] | 48 | 8 | 32 | 8 | 16 | 8 | 48 | 60 | 24 | 40 | 8 | 16 | 48 | 24 | 24 | 412 |
| Total hours | 376 | 188 | 728 | 244 | 220 | 104 | 772 | 240 | 152 | 680 | 264 | 280 | 168 | 268 | 136 | 4820 |
| | JT | HG | GK | KM | RM | JM | AR | SS | WS | DT | PV | JW | PB | LD | SF | |

a. Task 8 includes all interfaces with the Oversight Panel and public.

## E. INTERFACE WITH THE OVERSIGHT PANEL

The success of this project depends on establishing a good working relationship between the Oversight Panel and *RAC*. Information, ideas, concerns, and suggestions must flow freely between *RAC* and the Oversight Panel for the relationship to work. In addition, professional respect between the Oversight Panel and *RAC* must be established. *RAC* has had considerable experience working with Oversight Panels during performance of three dose reconstruction projects. For example, over the past three years, *RAC* scientists have spent a considerable amount of time and effort beyond the contract specifications in addressing concerns of the Health Advisory Panel and the public for the Historical Public Exposures Studies at Rocky Flats.

During the course of this project, key *RAC* personnel will meet with the Oversight Panel at their regularly scheduled monthly meetings. At each meeting, *RAC* personnel will inform the panel of their latest findings, seek advice from the panel on future directions, recommend alternative approaches, and respond to concerns and requests made by panel members. *RAC* will provide copies of their presentations and draft reports for review by the Oversight Panel. Outside of the monthly meetings, *RAC* personnel will be available via telephone, e-mail, fax or if necessary, a personal visit.

## F. PEER REVIEW

The credibility of any scientific endeavor is gained through peer review. *RAC* is committed to this general principle in all of its work and believes peer review to be essential to the credibility of any scientific investigation. In past projects, *RAC* has solicited advice from oversight panels and concerned citizens to identify potential peer reviewers. *RAC* has also been open to peer review by individuals representing all sides of a scientific issue. We are open to reviews by scientific panels such as the National Academy of Sciences and The Natural Resources Defense Council. We are committed to an open review policy for all our work.

*RAC* will suggest peer reviewers based on (a) their overall reputation and credibility in the scientific community, (b) their expertise in the particular area of work to be reviewed and (c) the absence of conflict of interest issues. *RAC* will also solicit suggestions from panel members and concerned members of the public. Reviewers that are currently outside the DOE system are preferable; however, *RAC* recognizes that a significant portion of the expertise in this field resides in the national laboratory system, and the individuals who possess this expertise cannot be ignored. A list of potential reviewers will be provided to the Oversight Panel two months into the project. Panel members will have a month to review the list and provide suggested changes to *RAC*. Upon agreement between *RAC* and the Oversight Panel concerning the list of potential reviewers, reviewers will be contacted and their availability assured. Individuals who are unable to participate will be removed from the list and new ones suggested. After all reviewers are confirmed, a timetable for review will be presented to the Oversight Panel.

Our experience has shown that peer review typically takes longer than expected. Therefore in most cases, we have allowed two to three months for review and incorporation of comments into the final documents.

## G. WORK SCHEDULE

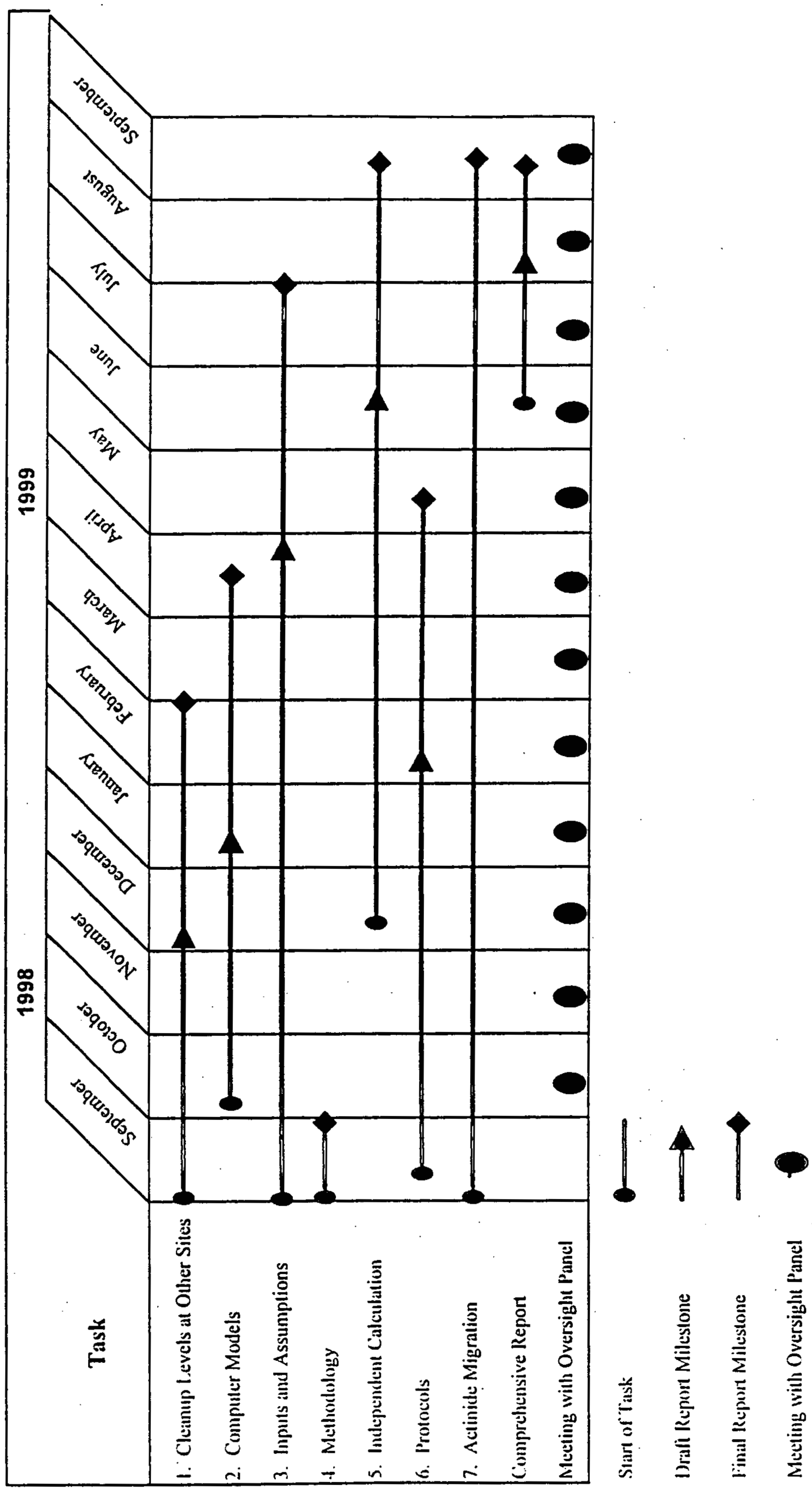
The schedule of proposed work is described in Table 3. The schedule has been arranged for completion within the one-year time frame as stipulated in the RFP and includes milestones for draft and final reports. Each task listed in the Proposal of Work is stated in the schedule. In addition, we have identified the comprehensive summary report and meetings with Oversight Panel in the schedule.

## H. CONFLICT OF INTEREST

Conflict of interest is a significant issue of concern that must be addressed if this project is to be carried out successfully. This includes both the potential for conflict of interest and the public's perception of a conflict of interest. A potential for conflict of interest may arise if key personnel on the *RAC* Team have close ties to DOE, the RFETS site contractor, or any other party that may stand to benefit from the outcome of this study. No *RAC* Team member has a close tie to DOE, the site contractor, or any party who may stand to benefit from the study. Mr. Rood is employed part-time by Lockheed Martin Idaho Technologies Corporation, the prime contractor to the INEEL. His work there currently involves a field survey of naturally occurring radioactive material and environmental transport modeling in support of low-level waste performance assessments. Mr. Rood's involvement with the INEEL in no way influences DOE policy at the RFETS. In addition, his arrangement INEEL has not been a problem with his current involvement in the Historical Public Exposures Studies at Rocky Flats. None of the contracts that *RAC* or *RAC* Team members are currently involved with is for or controlled by DOE, the site contractor, or any other party that may stand to benefit from the outcome of this study. For this reason, *RAC* concludes that no conflict of interest exists for this project.

*RAC* has been a strong proponent of independence in research related to the nuclear weapons complex. Dr. Till, as chair of the Technical Steering Panel for the Hanford Environmental Dose Reconstruction Project, was an outspoken advocate of the panel's independence and contributed significantly to separation between DOE and health-related research that now exists. For this reason, *RAC* has been awarded a number of research projects not only for their high-quality research but also because of their independence.

**Table 3. Work Schedule**



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## FEES BID

### Introduction

This offer is predicated upon all the terms and conditions of the Request for Proposals issued by the Rocky Flats Citizens Advisory Board (RFCAB). The total cost of the proposed work is $499.484.05.

### Small Business Enterprise.

*Risk Assessment Corporation* (*RAC*) is a small business concern. The company asserts that it is independently owned and operated. has no interest of foreign ownership. and meets the size standards for a small business under government regulations.

### Assurances and Certifications

Terms of the required assurances and certifications are accepted for any resulting contract

### Cost and Pricing Data

All costs are broken down in the itemized costs discussed below. Itemized costs are shown on the costing worksheet included in this business proposal. A brief description of key cost items follows.

**Direct Labor.** Direct labor consists of time offered by Dr. Till, and does not include time for other members of the *RAC* Team who work with *RAC* as independent contractors. It is estimated that direct labor for the research would require approximately 376 hours of Dr. Till's time, considered to be approximately 19% of the total available time in a year. Dr. Till's rate for this project is $80 per hour resulting in a direct labor fee for the 12-month contract of $30,080.

| Direct labor | $/hr |
|---|---|
| Hourly rate | $ 80.00 |
| Number of hours | 376.00 |
| **Total direct labor** | **$30,080.00** |

**Labor Overhead.** The labor overhead rate is 20.29% (to be billed at actual rate) of direct labor. This rate has been established with the Centers for Disease Control and Prevention.

| Labor overhead | @20.29% |
|---|---|
| **Total overhead** | **$6,103.23** |

**Travel.** *Risk Assessment Corporation* travel regulations are defined later in this cost estimate. It is estimated that travel costs over the 12-month contract will be $44.828.

***RAC* Independent Contractors.** *RAC* Team members work as independent contractors to the company. Hourly rates include all overhead and operating expenses for the Team member. Individuals available to work on the project are listed below with their hourly rates. Biographical sketches for each Team member are included in this proposal. Total cost for the Team member support is based on each member's estimated number of hours of support. This level of detail is provided in the attached cost sheets.

| *RAC* Team member | $/hr |
|---|---|
| Phoebe Boelter | $55.00 |
| Leeann Denham | 71.50 |
| Sally Francis | 38.00 |
| Helen Grogan | 80.00 |
| George Killough | 90.00 |
| Kathleen Meyer | 90.00 |
| Robert Meyer | 90.00 |
| Justin Mohler | 65.00 |
| Arthur Rood | 80.00 |
| Susan Sharp | 73.30 |
| Warren Sinclair | 100.00 |
| David Thorne | 73.40 |
| Paul Voillequé | 90.00 |
| Jill Weber | 65.00 |
| **Total cost** | **$348,347.20** |

**Other Direct Costs.** Expenses in the amount of $4,900.00 for the production and mailing of reports have been included in this business proposal.

**General and Administrative Expenses.** The current rate for general and administrative (G&A) expenses has been established by the Centers for Disease Control and Prevention and the Colorado Department of Health and is calculated monthly and billed at the actual rate based on a 12-month average. The estimated G&A expense for this project is 8%.

**Profit.** Profit is figured at 6.5% of the total costs.

**Total Project Cost.** The total project costs are summarized below.

| **Total project costs** | |
|---|---|
| **Item** | **Cost** |
| Direct labor | $30,080.00 |
| Labor overhead @ 21% | 6,103.23 |
| Labor and labor overhead | 36,183.23 |
| Travel | 44,828.00 |
| *RAC* Team members | 348,347.20 |
| Other direct costs | 4,900.00 |
| G&A estimated at 8% | 34,740.67 |
| Profit at 6.5% | 30,484.94 |
| **Total contract costs** | **$499,484.05** |

**Description of Accounting System.** *Risk Assessment Corporation* is on an accrual accounting system. No plans are anticipated for changing the accounting system during the course of the work.

**Travel Regulations** *(Risk Assessment Corporation).* Travel for *Risk Assessment Corporation* will be by the most direct route and reimbursed at the air coach or air tourist rate (less than first class rate, unless use of coach fare is clearly unreasonable or impractical, e.g., not available for reasons other than avoidable delay in making reservations, requirement of circuitous routing, additional expense offsetting the savings on fare, or flight would not make necessary connections).

Reimbursement of costs for lodging, meals, and incidental expenses incurred shall be considered reasonable and allowable to the extent that they do not exceed on a daily basis the per diem rates set forth in the Federal Travel Regulations. Expenses incurred above these limits will be borne by the traveler.

Receipts for items in excess of $25. Claims for travel will be submitted at the end of the calendar month during which travel was completed.

## Other Administrative Data

**Commitment by *Radiological Assessments Corporation*.** This proposal is predicated upon all the terms and conditions of the Request for Proposals and is a firm commitment by *Risk Assessment Corporation* for a period of 120 days from the date of receipt by the Government.

**Contact Regarding Accounting System.** Questions concerning the *RAC* accounting system should be addressed to

| | | |
|---|---|---|
| Dr. John E. Till | or | Mr. Joe Binnicker |
| *Risk Assessment Corporation* | | C.C. McGregor and Co. |
| Telephone 803-536-4883 | | Telephone 803-536-1015 |

**Cognizant Government Auditing Agency.** Questions concerning *RAC* audit status should be addressed to

Barry E. Smith
Centers for Disease Control and Prevention, M.S. E-26
255 East Paces Ferry Road, NE, Room 314
Atlanta, GA 30305
Telephone 404-842-6787.

**Statement of Financial Capacity.** *Risk Assessment Corporation* will perform this work without assistance from any outside source.

**Publications and Patent Rights.** *Risk Assessment Corporation* reserves the right to publish the results of original work it produces in the open scientific literature. There are no patents expected to be produced as part of this project.

**Cost Worksheets.** Worksheets used in developing the costs for this project are included on the following pages.

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## Travel Costs

| | | John Till | Helen Grogan | George Killough | Kathleen Meyer | Robert Meyer | Justin Mohler | Art Rood | Susan Sharp | Warren Sinclair | David Thorne | Paul Voilleque | Jill Weber | Phoebe Boelter | Leeann Denham | Sally Francis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # trips | Denver | 4 | 0 | 0 | 6 | 4 | 2 | 10 | 4 | 1 | 6 | 3 | 3 | 0 | 0 | 0 |
| | Chastn | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| days/trip | Denver | 3 | 0 | 0 | 1 | 1 | 3 | 3 | 2 | 3 | 1 | 3 | 4 | 0 | 0 | 0 |
| | Chastn | 0 | 2 | 3 | 22 | 0 | 0 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 2 | 2 |

**Per diem per location plus car rental**

| Denver | Chastn | Car/day |
|---|---|---|
| 103 | 85 | 50 |

**Airfare (or mileage costs) per trip**

| | | JT | HG | GK | KM | RM | JM | AR | SS | WS | DT | PV | JW | PB | LD | SF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Denver | 1200 | 0 | 0 | 35 | 35 | 400 | 400 | 1000 | 500 | 400 | 400 | 600 | 0 | 0 | 1000 |
| | Chastn | 0 | 1200 | 210 | 1200 | 0 | 0 | 1200 | 1200 | 0 | 1200 | 1200 | 1200 | 700 | 400 | 700 |
| Total Car | | 600 | | | | 200 | | 1600 | | | | | | | | |
| Total Air/private vehi | | 4800 | 1200 | 420 | 1410 | 140 | 800 | 5200 | 5200 | 500 | 3600 | 2400 | 3000 | 700 | 400 | 700 |
| Total per diem | | 1236 | 170 | 510 | 2488 | 412 | 618 | 3260 | 994 | 309 | 788 | 1097 | 1406 | 170 | 0 | 100 |
| Total Travel | | $6,636 | $1,370 | $930 | $3,898 | $752 | $1,418 | $8,460 | $6,194 | $809 | $4,388 | $3,497 | $4,406 | $870 | $400 | $800 |

Travel: Item 1

**Total Travel Costs = $44,828**

**Basis for time estimates, by individual and task**

| Task | John Till | Helen Grogan | George Killough | Kathleen Meyer | Robert Meyer | Justin Mohler | Art Rood | Susan Sharp | Warren Sinclair | David Thorne | Paul Voilleque' | Jill Weber | Phoebe Boelter | Leeann Denham | Sally Francis | Total Hours/task |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Task 1: Clean-up Levels at Other Sites** | | | | | | | | | | | | | | | | |
| 1a: Soil Action Levels at Other Sites | 24 | 8 | 16 | 8 | 8 | 8 | 20 | 8 | 0 | 16 | 8 | 8 | 0 | 12 | 0 | |
| 1b: Reporting | 16 | 0 | 16 | 8 | 8 | 8 | 24 | 8 | 0 | 16 | 8 | 16 | 20 | 8 | 20 | 320 |
| **Task 2: Computer Models** | | | | | | | | | | | | | | | | |
| 2a: Search and Acquisition | 4 | 16 | 48 | 8 | 8 | 0 | 32 | 16 | 0 | 32 | 16 | 24 | 0 | 16 | 0 | |
| 2b: Testing and Analysis | 8 | 16 | 80 | 8 | 8 | 0 | 56 | 16 | 0 | 56 | 16 | 24 | 0 | 16 | 0 | |
| 2c: Reporting | 24 | 16 | 32 | 8 | 8 | 0 | 32 | 8 | 0 | 32 | 8 | 16 | 20 | 12 | 20 | 760 |
| **Task 3: Inputs and Assumptions** | | | | | | | | | | | | | | | | |
| 3a: Preliminary uncertainty analysis | 4 | 8 | 24 | 8 | 8 | 4 | 16 | 4 | 0 | 16 | 8 | 8 | 0 | 8 | 0 | |
| 3b: Develop parameter distributions | 8 | 8 | 32 | 8 | 8 | 4 | 48 | 4 | 0 | 32 | 8 | 8 | 0 | 12 | 0 | |
| 3c: Evaluate exposure scenarios | 8 | 8 | 24 | 8 | 8 | 4 | 24 | 4 | 0 | 24 | 8 | 8 | 0 | 8 | 0 | |
| 3d: Program setup for Monte Carlo | 8 | 8 | 32 | 8 | 8 | 4 | 48 | 4 | 0 | 32 | 8 | 8 | 0 | 12 | 0 | |
| 3e: Post process and interpret results | 8 | 8 | 24 | 8 | 8 | 4 | 24 | 4 | 0 | 24 | 8 | 8 | 0 | 8 | 0 | |
| 3f: Reporting | 24 | 8 | 48 | 8 | 8 | 8 | 56 | 8 | 0 | 48 | 8 | 8 | 20 | 12 | 20 | 1032 |
| **Task 4: Methodology** | | | | | | | | | | | | | | | | |
| 4a: Prepare presentation | 16 | 0 | 24 | 8 | 8 | 0 | 32 | 8 | 8 | 24 | 8 | 16 | 8 | 8 | 0 | 168 |
| **Task 5: Independent Calculation** | | | | | | | | | | | | | | | | |
| 5a: Program Setup for Monte Carlo | 8 | 8 | 24 | 8 | 8 | 8 | 24 | 8 | 8 | 24 | 8 | 16 | 0 | 12 | 0 | |
| 5b: Calculation of SALs | 16 | 8 | 56 | 8 | 8 | 8 | 56 | 8 | 32 | 56 | 16 | 24 | 0 | 16 | 0 | |
| 5c: Development of risk estimates | 16 | 0 | 16 | 8 | 8 | 8 | 16 | 8 | 56 | 16 | 8 | 8 | 0 | 8 | 0 | |
| 5d: Reporting | 16 | 8 | 48 | 4 | 4 | 8 | 48 | 8 | 24 | 32 | 8 | 16 | 20 | 12 | 20 | 928 |
| **Task 6: Protocols** | | | | | | | | | | | | | | | | |
| 6a: Review Existing Procedures/protocols | 8 | 24 | 48 | 24 | 4 | 4 | 48 | 8 | 0 | 56 | 24 | 24 | 0 | 16 | 0 | |
| 6b: Determination of sampling protocol | 8 | 16 | 24 | 8 | 4 | 4 | 24 | 8 | 0 | 32 | 16 | 16 | 0 | 8 | 0 | |
| 6c Evaluation of QA methods | 8 | 4 | 16 | 8 | 8 | 4 | 16 | 8 | 0 | 24 | 8 | 0 | 0 | 4 | 0 | |
| 6d: Reporting | 24 | 8 | 40 | 16 | 8 | 8 | 40 | 16 | 0 | 40 | 8 | 8 | 20 | 16 | 20 | 836 |
| **Task 7: Actinide Migration** | | | | | | | | | | | | | | | | |
| 7a: Meet with Actinide Migration Panel | 32 | 0 | 0 | 32 | 32 | 0 | 8 | 16 | 0 | 8 | 16 | 0 | 0 | 4 | 0 | |
| 7b: Evaluate other pathways | 8 | 0 | 8 | 8 | 8 | 0 | 8 | 0 | 0 | 0 | 8 | 0 | 0 | 4 | 0 | |
| 7c: Identify data gaps | 8 | 0 | 8 | 8 | 8 | 0 | 8 | 0 | 0 | 0 | 8 | 0 | 0 | 4 | 0 | |
| 7d: Reporting | 24 | 0 | 8 | 8 | 8 | 0 | 16 | 0 | 0 | 0 | 16 | 0 | 12 | 8 | 12 | 364 |
| **Task 8. Interfacing and Responsibilities**[a] | 48 | 8 | 32 | 8 | 8 | 8 | 48 | 60 | 24 | 40 | 8 | 16 | 48 | 24 | 24 | |
| **Total hours** | 376 | 188 | 728 | 244 | 212 | 104 | 772 | 240 | 152 | 680 | 264 | 280 | 168 | 268 | 136 | 4812 |
| | JT | HG | GK | KM | RM | JM | AR | SS | WS | DT | PV | JW | PB | LD | SF | |

[a]Task 8. Includes all aspects of public involvement and interaction with the Panel

**Total project hours 4,812**

Labor costs

| | John Till | Helen Grogan | George Killough | Kathleen Meyer | Robert Meyer | Justin Mohler | Art Rood | Susan Sharp | Warren Sinclair | David Thorne | Paul Voillequé | Jill Weber | Phoebe Boelter | Leeann Denham | Sally Francis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hourly Rate** | 80 | 80 | 90 | 90 | 90 | 65 | 80 | 73.3 | 100 | 73.4 | 90 | 65 | 55 | 71.5 | 38 |
| **Task 1: Clean-up Levels at Other Sites** | | | | | | | | | | | | | | | |
| 1a: Soil Action Levels at Other Sites | 1920 | 640 | 1440 | 720 | 720 | 520 | 1600 | 586 | 0 | 1174 | 720 | 520 | 0 | 858 | 0 |
| 1b: Reporting | 1280 | 0 | 1440 | 720 | 720 | 520 | 1920 | 586 | 0 | 1174 | 720 | 1040 | 1100 | 572 | 760 |
| **Task 2: Computer Models** | | | | | | | | | | | | | | | |
| 2a: Search and Acquisition | 320 | 1280 | 4320 | 720 | 720 | 0 | 2560 | 1173 | 0 | 2348 | 1440 | 1560 | 0 | 1144 | 0 |
| 2b: Testing and Analysis | 640 | 1280 | 7200 | 720 | 720 | 0 | 4480 | 1173 | 0 | 4110 | 1440 | 1560 | 0 | 1144 | 0 |
| 2c: Reporting | 1920 | 1280 | 2880 | 720 | 720 | 0 | 2560 | 586 | 0 | 2348 | 720 | 1040 | 1100 | 858 | 760 |
| **Task 3: Inputs and Assumptions** | | | | | | | | | | | | | | | |
| 3a: Perform preliminary uncertainty analysis | 320 | 640 | 2160 | 720 | 720 | 260 | 1280 | 293 | 0 | 1174 | 720 | 520 | 0 | 572 | 0 |
| 3b: Develop parameter distributions | 640 | 640 | 2880 | 720 | 720 | 260 | 3840 | 293 | 0 | 2348 | 720 | 520 | 0 | 858 | 0 |
| 3c: Evaluate exposure scenarios | 640 | 640 | 2160 | 720 | 720 | 260 | 1920 | 293 | 0 | 1761 | 720 | 520 | 0 | 572 | 0 |
| 3d: Program setup for Monte Carlo | 640 | 640 | 2880 | 720 | 720 | 260 | 3840 | 293 | 0 | 2348 | 720 | 520 | 0 | 858 | 0 |
| 3e: Post process and interpret results | 640 | 640 | 2160 | 720 | 720 | 260 | 1920 | 293 | 0 | 1761 | 720 | 520 | 0 | 572 | 0 |
| 3f: Reporting | 1920 | 640 | 4320 | 720 | 720 | 520 | 4480 | 586 | 0 | 3523 | 720 | 520 | 1100 | 858 | 760 |
| **Task 4: Methodology** | | | | | | | | | | | | | | | |
| 4a: Prepare presentation | 1280 | 0 | 2160 | 720 | 720 | 0 | 2560 | 586 | 800 | 1761 | 720 | 1040 | 440 | 572 | 0 |
| **Task 5: Independent Calculation** | | | | | | | | | | | | | | | |
| 5a: Program Setup for Monte Carlo | 640 | 640 | 2160 | 720 | 720 | 520 | 1920 | 586 | 800 | 1761 | 720 | 1040 | 0 | 858 | 0 |
| 5b: Calculation of SALs | 1280 | 640 | 5040 | 720 | 720 | 520 | 4480 | 586 | 3200 | 4110 | 1440 | 1560 | 0 | 1144 | 0 |
| 5c: Development of risk estimates | 1280 | 0 | 1440 | 720 | 720 | 520 | 1280 | 586 | 5600 | 1174 | 720 | 520 | 0 | 572 | 0 |
| 5d: Reporting | 1280 | 640 | 4320 | 360 | 360 | 520 | 3840 | 586 | 2400 | 2348 | 720 | 1040 | 1100 | 858 | 760 |
| **Task 6: Protocols** | | | | | | | | | | | | | | | |
| 6a: Review Existing Procedures/protocols | 640 | 1920 | 4320 | 2160 | 360 | 260 | 3840 | 586 | 0 | 4110 | 2160 | 1560 | 0 | 1144 | 0 |
| 6b: Determination of sampling protocol | 640 | 1280 | 2160 | 720 | 360 | 260 | 1920 | 586 | 0 | 2348 | 1440 | 1040 | 0 | 572 | 0 |
| 6c Evaluation of QA methods | 640 | 320 | 1440 | 720 | 720 | 260 | 1280 | 586 | 0 | 1761 | 720 | 0 | 0 | 286 | 0 |
| 6d: Reporting | 1920 | 640 | 3600 | 1440 | 720 | 520 | 3200 | 1173 | 0 | 2936 | 720 | 520 | 1100 | 1144 | 760 |
| **Task 7: Actinide Migration** | | | | | | | | | | | | | | | |
| 7a: Meet with Actinide Migration Panel | 2560 | 0 | 0 | 2880 | 2880 | 0 | 640 | 1173 | 0 | 587 | 1440 | 0 | 0 | 286 | 0 |
| 7b: Evaluate other pathways | 640 | 0 | 720 | 720 | 720 | 0 | 640 | 0 | 0 | 0 | 720 | 0 | 0 | 286 | 0 |
| 7c: Identify data gaps | 640 | 0 | 720 | 720 | 720 | 0 | 640 | 0 | 0 | 0 | 720 | 0 | 0 | 286 | 0 |
| 7d: Reporting | 1920 | 0 | 720 | 720 | 720 | 0 | 1280 | 0 | 0 | 0 | 1440 | 0 | 660 | 572 | 456 |
| **Task 8. Interfacing and Responsibilities**[a] | 3840 | 640 | 2880 | 720 | 720 | 520 | 3840 | 4398 | 2400 | 2936 | 720 | 1040 | 2640 | 1716 | 912 |
| Total labor costs | 30080 | 15040 | 65520 | 21960 | 19080 | 6760 | 61760 | 17592 | 15200 | 49905 | 23760 | 18200 | 9240 | 19162 | 5168 |

**Total Direct Labor (John Till) = $30.080**

**Total Consultant Costs = $348.347.20**

Item 2:
Labor Costs

Item 3:
Consultant Costs

## Production and Mailing of Reports

| | | | |
|---|---|---|---|
| **Draft Report** (100 Copies of 100-page Report, 15 Copies of 500-page Appendix including Disk | | | $ 2,450.00 |
| | Printing | $ 2,000.00 | |
| | Postage to mail 50 copie | $ 250.00 | |
| | Ship Remainder to Pane | $ 200.00 | |
| **Final Report** (100 Copies of 100-page Report, 15 Copies of 500-page Appendix including Disk | | | $ 2,450.00 |
| | Printing | $ 2,000.00 | |
| | Postage to mail 50 copie | $ 250.00 | |
| | Ship Remainder to Pane | $ 200.00 | |
| | Total Report Production & Mailing | | $4,900.00 |

Item 4: Report Production/Distrbtn.

## Total Estimated Costs

Item 2

Item 1

Item 3

Item 4

| | | | | |
|---|---|---|---|---|
| Direct Labor | $30,080.00 | | | |
| Labor overhead @ 20.29 | $6,103.23 | | | |
| Total labor and labor overhead | | $36,183.23 | | |
| Travel | | $44,828.00 | | |
| Consultants | | $348,347.20 | | |
| Other (preparation of reports) | | $4,900.00 | | |
| Subtotal of above | | $434,258.43 | | |
| G&A is estimated to be 8% (G&A will be billed as actual) | | | $34,740.67 | |
| Subtotal of above | | | $468,999.11 | |
| Profit at 6.5% | | | | $30,484.94 |
| Rocky Flats Soil Action Levels Grand Total | | | = | $499,484.05 |



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